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# Environmental Policy Theory Given Bounded Rationality and Other-regarding Preferences

Elisabeth Gsottbauer · Jeroen C. J. M. van den Bergh

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**Abstract** Established environmental policy theory is based on the assumption of *homo economicus*. This means that people are seen as fully rational and acting in a self-regarding manner. In line with this, economics emphasizes efficient policy solutions and the associated advantages of price incentives. Behavioral economics offers alternative, more realistic views on individual behavior. In this paper we investigate opportunities to integrate bounded rationality and other-regarding preferences into environmental policy theory to arrive at recommendations for more effective policies. For this purpose, we will address decisions made under risk and uncertainty, intertemporal choice, decision heuristics, other-regarding preferences, heterogeneity, evolutionary selection of behaviors, and the role of happiness. Three aspects of environmental policy are considered in detail, namely sustainable consumption, environmental valuation and policy design. We pay special attention to the role of non-pecuniary, informative instruments and illustrate the implications for climate policy.

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## 1 Introduction

A good understanding of individual behavior and decision-making is essential to explain and predict how people will act concerning environmental issues and subject to specific environmental policies. Although behavioral economics enjoys increasing support, systematic application of its theories and insights to economic sub-disciplines like environmental economics is still very limited and has not resulted in a systematic set of policy recommendations. This paper sets out to offer a summary of findings on human behavior and their implications for environmental policy.

Economics traditionally uses a model of behavior commonly referred to as *homo economicus* to analyze the economic behavior of individuals when subject to public policy. This economic being is endowed with given preferences, perfect rationality and self-interest. Human action is reduced to an optimization problem: behavior can be fully explained by individuals maximizing their utility. This approach assumes that preferences are fixed and that behavior is influenced only by prices and income. In line with this, economic analysis proposes that generally a proper, socially desirable allocation of private and public goods is achieved where prices direct economic decisions. Policy advice drawing on standard theory suggests the use of monetary incentives to influence behavior. A clear example is environmental policy theory, developed by [Baumol and Oates \(1975\)](#), where price corrections capture negative environmental externalities.

Behavioral economics offers an alternative explanation of human action based on recognizing bounded rationality and limited self-interest. Economic psychology has provided a great amount of evidence against the neoclassical-economic model of individual behavior and, in response, a range of alternative theories of behavior and models of choice have been developed. Some influential studies are [Simon \(1955\)](#), [Kahneman and Tversky \(1974\)](#), [Kahneman and Tversky \(1979\)](#), [Thaler \(1980\)](#), [Andreoni \(1990\)](#), [Rabin \(1993\)](#) and [Fehr and Schmidt \(1999\)](#). Behavior not complying with the standard model can be categorized as “bounded or limited rationality” when decisions are constrained by cognitive processes and available information, and as “other-regarding behavior” when motives like fairness, reciprocity, and self-identity affect decisions. There are several good reviews now summarizing findings from behavioral economics ([Kahneman et al. 1986](#); [Camerer 1995](#); [Conlisk 1996](#); [Rabin 1998](#); [McFadden 1999](#); [Camerer et al. 2004](#); [Lorenzoni et al. 2007](#); [Meier 2007](#)). A few articles have addressed the application of behavioral theories to environmental economics focusing on particular instances ([van den Bergh et al. 2000](#); [Shogren 2002](#); [Shogren and Taylor 2008](#); [Venkatachalam 2008](#); [Gowdy 2008](#); [Brekke and Johansson-Stenman 2008](#)).

The aim of the current paper is to reflect on the main alternative assumptions of behavioral economics so as to be able to offer a more realistic account of effective and efficient environmental policy. Designing adequate policies and incentives requires a good understanding of how people behave and make decisions within different contexts. Insight into behavioral failures and motives other than self-interest can lead to adjustments of traditional advice on policy design. This involves assessing responsiveness to policy incentives and interventions, drivers of consumer choice, and non-economic factors affecting individual decision-making.

The remainder of this paper is organized as follows. Section 2 offers a brief overview of behavioral economics and responses to it. This involves a classification of behavioral failures and motives violating rationality and other preference assumptions, notably regarding social context. Section 3 discusses several other ideas that extend, or may be combined with, the behavioral economics approach, namely preference heterogeneity, decisions by groups and organizations, a non-representative agent approach, population models in evolutionary economics, and insights from research on happiness or subjective well-being. Section 4 reviews applications of behavioral economics to environmentally relevant behavior, focusing on environmental valuation and sustainable consumption. Section 5 discusses lessons for environmental policy under bounded rationality and other-regarding preferences, paying particular attention to non-pecuniary incentives and the topical issue of climate policy. Finally, Section 6 concludes while Section 7 discusses potential research avenues.

## 2 An Overview of Bounded Rationality and Other-Regarding Preferences

Behavioral economics strives to integrate the psychological foundations of human behavior into economic analysis. It relies on evidence generated mainly by laboratory and, to a lesser extent, natural or field experiments. These generally find that individuals systematically deviate from rational decision-making. This involves two main insights. Firstly, people do not make optimal decisions, as they are boundedly rational due to cognitive limits, lack of information and limited willpower. For instance, people regularly use decision heuristics—so-called rules of thumb or decision shortcuts. Secondly, people have limited self-interest, i.e. they are also driven by other-regarding preferences like fairness or reciprocity when making decisions. Many examples of such behavior exist in the context of consumption activities: heuristics and mental accounts influence product choice (Cheema and Soman 2006), pro-social behavior affects donations or volunteering (Meier and Stutzer 2008), and status and habits drive consumption (Lindbeck 1997). Behavioral economists have opened the way to alternative models of behavior which adjust or replace the rational, maximization model and its predictions, such as prospect theory, hyperbolic discounting, heuristics, habitual behavior, status seeking, self-identity concerns, and theories involving social preferences.

As one might expect, there is also criticism of behavioral economics. This stresses two lines of reasoning to justify the relevance of rational agents: market selection (evolution) and learning (summarized by Mullainathan and Thaler 2000). Several economists have argued that behavioral failures do not matter in the market as they are eliminated or mitigated by mechanisms like arbitrage and competition. By contrast, behavioral economists claim that there are limits to arbitrage. This has been repeatedly shown in research on financial markets where individuals are found to regularly deviate from behavior as predicted by expected utility theory. Financial theory has, in fact, moved in the direction of behavioral models in response to the bounded rationality of investors (Levy et al. 2000; Shleifer 1999).

Another line of criticism states that the presence of evolutionary mechanisms supports the irrelevance of behavioral anomalies. However, evolution is consistent with bounds on rationality and should not be simplified as leading to optimal behavior. Alchian (1950), who argued that firms that are profit seekers and those successful in achieving profits will be selected by the market mechanism and survive. Friedman (1953) even went further and proposed that profit “maximization” rather than “seeking” is selected by the market, thus trying to find support for the idea that profit maximization, although not universal, will be the sure outcome of selection by the market. Winter (1964) criticized both previous authors, arguing that the explanation lacks a transmission mechanism for successful behavior.

As a result, winning in one period is unrelated to winning in another period. If profit seeking or maximizing is not deliberate or conscious, then it cannot be passed on to, or learned by, others (Hodgson 1988: p. 78). This means winning remains a largely random process, as shown by the profits of many firms fluctuating erratically over time. Moreover, even if the Alchian-Friedman argument was correct, it would only pertain to profit, not utility maximization. In other words, the rational consumer behavior model would have to be saved by a different type of argument. Another, more recent criticism on the foregoing evolutionary argument in favor of rationality comes from behavioral economists who claim that there are limits to arbitrage. This has been repeatedly shown in research on financial markets where individuals are found to regularly deviate from behavior as predicted by expected utility theory. Financial theory has, in fact, moved in the direction of behavioral models in response to the bounded rationality of investors (Levy et al. 2000; Shleifer 1999).

A second defense of rational choice theory is as follows. Individuals who systematically make mistakes might learn to overcome them. However, instead of costly investment in increasing knowledge, learning often takes the form of low-cost, social learning through imitation of frequent behavior or superficial features of successful behavior without understanding the nature of such success (Boyd and Richerson 1993). This comes down to agents copying the behavior of other boundedly rational agents, which does not lead to rational behavior.

Behavioral economics relies strongly on evidence generated by experiments. These have, however, been criticized for lacking external validity, meaning that behavior assessed in experiments might not correlate with, or resemble, real-world behavior. Empirical evidence and observations outside the experimental laboratory can overcome problems with external validity. Already Simon (1986, 209) acknowledged that behavioral economics requires “[...] an empirically founded theory of choice that specifies what information decision makers use and how they actually process it. This behavioral empirical base [...] is essential for enhancing the explanatory and predictive power of economics”. In response, attention has shifted somewhat to field and large-scale social experiments. These provide empirical evidence on the relationship between laboratory and field behavior (List 2006; Cardenas and Carpenter 2008; Ehmke and Shogren 2008). On one hand, such studies confirm many of the findings on bounded rationality of laboratory experiments and thus provide support for the validity of lab results. On the other hand some studies suggest that bounded rationality is slightly less pronounced in the field. Recently, laboratory experiments have even questioned the robustness of certain behavioral failures. For example, Gunnarsson et al. (2003) find that market arbitrage removes preference reversals, while Cherry et al. (2003) find a similar result for environmental lotteries.

We classify insights from behavioral economics into two broad themes: bounded rationality and limited self-interest. Bounded rationality involves behavioral anomalies<sup>1</sup> in choice under risk and uncertainty, intertemporal choice, and other inconsistencies in decision-making. Other-regarding preferences or limited self-interest includes all types of other-regarding behavior and motivations, such as fairness, altruism, reciprocity and preferences for self-identity like status. In line with these various behavioral categories we consider relevant alternative behavioral theories. Table 1 provides a summary.

<sup>1</sup> Similar terms like behavioral anomaly, deviation, failure, bias and judgment problems describe behavior deviating from perfect rationality.

**Table 1** Concepts and theories in behavioral economics

| General category    | Specific category                 | Rational choice theory    | Behavioral theory                                       | Main behavioral insights  | Behavioral anomalies and other-regarding preferences | Effects                             |
|---------------------|-----------------------------------|---------------------------|---|---|--|-------------------------------------|
| Bounded rationality | Choice under risk and uncertainty | Expected utility theory   | Prospect theory and rank dependent utility theory       | Preferences violate the axioms of expected utility theory: they are reference-dependent, asymmetric to losses and gains and probabilities are weighted non-linearly | Reference-dependent preferences<br>Ambiguity         | Loss aversion                       |
|                     |                                   |                           |   |   |  | Certainty effect                    |
| Bounded rationality | Intertemporal choice              | Discounted utility theory | Time-inconsistent preferences and self-control problems | Time-inconsistent preferences affect individual's decision-making, i.e. valuing the present more than the future  | Hyperbolic discounting                               | Reflection effect                   |
|                     |                                   |                           |   |   |  | Isolation effect                    |
| Bounded rationality | Choice under risk and uncertainty | Expected utility theory   | Prospect theory and rank dependent utility theory       | Preferences violate the axioms of expected utility theory: they are reference-dependent, asymmetric to losses and gains and probabilities are weighted non-linearly | Reference-dependent preferences<br>Ambiguity         | Framing effect (bracketing)         |
|                     |                                   |                           |   |   |  | Endowment effect                    |
| Bounded rationality | Intertemporal choice              | Discounted utility theory | Time-inconsistent preferences and self-control problems | Time-inconsistent preferences affect individual's decision-making, i.e. valuing the present more than the future  | Hyperbolic discounting                               | Status quo effect                   |
|                     |                                   |                           |   |   |  | (superstition)                      |
| Bounded rationality | Choice under risk and uncertainty | Expected utility theory   | Prospect theory and rank dependent utility theory       | Preferences violate the axioms of expected utility theory: they are reference-dependent, asymmetric to losses and gains and probabilities are weighted non-linearly | Reference-dependent preferences<br>Ambiguity         | Equity-premium (disposition effect) |
|                     |                                   |                           |   |   |  | Asymmetric elasticity               |
| Bounded rationality | Intertemporal choice              | Discounted utility theory | Time-inconsistent preferences and self-control problems | Time-inconsistent preferences affect individual's decision-making, i.e. valuing the present more than the future  | Hyperbolic discounting                               | Default bias                        |
|                     |                                   |                           |   |   |  | Context effect                      |
| Bounded rationality | Choice under risk and uncertainty | Expected utility theory   | Prospect theory and rank dependent utility theory       | Preferences violate the axioms of expected utility theory: they are reference-dependent, asymmetric to losses and gains and probabilities are weighted non-linearly | Reference-dependent preferences<br>Ambiguity         | Preference reversal                 |
|                     |                                   |                           |   |   |  | Lexicographic preferences           |
| Bounded rationality | Intertemporal choice              | Discounted utility theory | Time-inconsistent preferences and self-control problems | Time-inconsistent preferences affect individual's decision-making, i.e. valuing the present more than the future  | Hyperbolic discounting                               | Ambiguity-aversion                  |
|                     |                                   |                           |   |   |  | Myopic behavior                     |
| Bounded rationality | Choice under risk and uncertainty | Expected utility theory   | Prospect theory and rank dependent utility theory       | Preferences violate the axioms of expected utility theory: they are reference-dependent, asymmetric to losses and gains and probabilities are weighted non-linearly | Reference-dependent preferences<br>Ambiguity         | Immediacy effect                    |
|                     |                                   |                           |   |   |  | Lack of self-control                |
| Bounded rationality | Intertemporal choice              | Discounted utility theory | Time-inconsistent preferences and self-control problems | Time-inconsistent preferences affect individual's decision-making, i.e. valuing the present more than the future  | Hyperbolic discounting                               | Magnitude effect                    |
|                     |                                   |                           |   |   |  | Sign effect (gain-loss asymmetry)   |
| Bounded rationality | Choice under risk and uncertainty | Expected utility theory   | Prospect theory and rank dependent utility theory       | Preferences violate the axioms of expected utility theory: they are reference-dependent, asymmetric to losses and gains and probabilities are weighted non-linearly | Reference-dependent preferences<br>Ambiguity         | Delay-speed up effect               |
|                     |                                   |                           |   |   |  | Sequence effect                     |
| Bounded rationality | Intertemporal choice              | Discounted utility theory | Time-inconsistent preferences and self-control problems | Time-inconsistent preferences affect individual's decision-making, i.e. valuing the present more than the future  | Hyperbolic discounting                               | Negative discounting                |
|                     |                                   |                           |   |   |  | “Gestalt” effect                    |
| Bounded rationality | Choice under risk and uncertainty | Expected utility theory   | Prospect theory and rank dependent utility theory       | Preferences violate the axioms of expected utility theory: they are reference-dependent, asymmetric to losses and gains and probabilities are weighted non-linearly | Reference-dependent preferences<br>Ambiguity         | Habit formation                     |
|                     |                                   |                           |   |   |  |                                     |

**Table 1** continued

| General category    | Specific category | Rational choice theory   | Behavioral theory | Main behavioral insights  | Behavioral anomalies and other-regarding preferences | Effects  |
|---------------------|-------------------|--|-------------------|---|--|--|
| Bounded rationality | Judgment          | Utility maximization under perfect information and perfect cognitive abilities | Heuristics        | Mechanisms underlying people's judgment and decision-making in order to overcome complexity and lack of information | Heuristics   | Availability<br>Representativeness<br>Anchoring and adjustment<br>Mental accounting  |
|                     |                   |  |                   |   | Judgment bias  | Self-serving bias<br>Overconfidence<br>Context effect<br>Focal effect<br>Isolation effect<br>Misinterpretation effect<br>Order effect<br>Process effect<br>Projection effect<br>Prominence effect<br>Rule-Driven behavior<br>Saliency effect<br>Emotions |

**Table 1** continued

| General category      | Specific category | Rational choice theory                           | Behavioral theory           | Main behavioral insights                            | Behavioral anomalies and other-regarding preferences | Effects   |
|-----------------------|-------------------|--|-----------------------------|---|--|---|
| Limited self-interest | Preferences       | Utility maximization under perfect self-interest | Other-regarding preferences | Individual utilities depart from pure self-interest | Social preferences                                   | Fairness (inequality aversion)<br>Altruism, impure altruism (warm glow)<br>Social norms (moral, intrinsic motivation)<br>Reciprocity, conditional cooperation<br>Status, relative income, positional goods<br>Social approval and disapproval |



## 2.1 Limited Rationality

Herbert [Simon \(1955\)](#) defined psychological principles of individual behavior and first recognized the imperfect access to information and limited computational capacities of individuals, which he called “bounded rationality”. Simon argued that only when choices are very simple and transparent does an individual behaves like a utility maximizer. However, when decisions are more complex, choices generally deviate from perfect rationality. In practice, decision-making occurs under time constraints, cognitive limitations and imperfect or costly information. According to Simon, people are then unable to maximize their utility and instead will “satisfice”, i.e. make a choice that is “good enough” ([Simon 1959](#)). Subsequent research has strongly supported Simon’s intuitive assessment of human behavior and its departures from rational choice axioms. Alternative theories of economic behavior grounded in psychological findings have been proposed and are presented next.

### 2.1.1 Choice Under Risk and Uncertainty

Many patterns of observed economic behavior under risk can not be explained by standard expected utility theory. Examples are people not cutting consumption expenditure after facing a wage cut, consumers usually choosing the default insurance offered to them, and cab drivers always quitting around daily income targets. Field observations ([Camerer 2004](#)) and laboratory experiments ([Kahneman et al. 1990](#)) describe such behavioral patterns. They find that utility depends on a reference point, and is sensitive to gains and losses relative to this point. This involves loss aversion, describing the fact that the disutility of giving up something is greater than the utility associated with acquiring something. This can explain the insensitivity of consumption to bad news about income or the tendency of cab drivers to work longer hours on “low-wage days”. Loss aversion can clarify a famous financial puzzle, namely the equity premium, with stocks having a much higher return than bonds ([Mehra and Prescott 1985](#)). An explanation for the large difference in returns found is that investors are loss-averse, demanding a higher premium as compensation for a higher risk of losing money.

Based on experimental findings, [Kahneman and Tversky \(1979\)](#) present an alternative model of choice, labeled prospect theory, which challenges standard expected-utility theory by integrating certain psychological aspects of decision-making. An important behavioral feature is that people overweight probabilities of outcomes that are considered certain in relation to other outcomes. This is called the certainty effect which involves a risk-averse preference for a sure gain over a probable gain with a larger expected value, and to a risk-seeking preference for a probable loss over a certain loss with a smaller expected value. A generalization of this is the reflection effect, which specifies that individuals are risk-averse when the outcome is positive and risk-seeking when it is negative. This can explain, for example, that people trading in stock markets hold losing stocks too long, and sell winning stocks too soon. In behavioral finance, this is known as the disposition effect. The isolation effect is an example of a decision anomaly from the viewpoint of expected-utility theory. Inconsistent preferences result from individuals basing their choices on differentiating characteristics between alternatives and not on shared characteristics.

The case of the decision maker being uncertain about probabilities of outcomes, referred to as ambiguity, represents another limitation to applying the expected-utility framework to individual decision making. Ambiguity is also referred to as Knightian uncertainty based on the seminal contribution of [Knight \(1921\)](#) who distinguished between measurable and unmeasurable uncertainty, i.e. ambiguity. Under conditions of ambiguity maximization of expected utility is not possible as this would imply knowing the probabilities of various outcomes.

Decisions under uncertainty are affected by whether decision makers are ambiguity-averse or not. According to [Ellsberg \(1961\)](#), people prefer situations involving precise probabilities (risk) to situations with unknown probabilities or ambiguity. Several experimental studies have examined ambiguity aversion (e.g., [Slovic and Tversky 1974](#); [Moore and Eckel 2003](#)). [Camerer and Weber \(1992\)](#) list different sources of ambiguity such as credibility of the information source, disagreements among experts, amount of available information, and weight of evidence. Many real life decisions involve ambiguous information about risk, such as vaccination decisions (negative health effects?), protection against environmental hazards (how likely is a natural disaster?) and adoption of innovations (which benefits?). Thus people are reluctant to vaccinate, buy insurance in order to self-protect against any uncertain outcomes, or buy a new, unknown product.

Another relevant bias is the framing effect, according to which individual choice between alternatives is affected by the way a problem is presented. [Kahneman and Tversky \(1979\)](#) framed a hypothetical choice about combating a disease in two different ways. Probabilities of events were the same, but in one case the alternatives were described in terms of saving people and in the other case in terms of deaths. The experiment showed that the certainty of saving people was judged disproportionately attractive, and the certainty of deaths disproportionately aversive, which violates classical expected utility theory. Other phenomena better explained by prospect theory than by standard theory are the endowment or status quo effect, the default bias and mental accounting.

The notion of placing a higher value on something we own has been repeatedly shown in experiments and also observed in real life situations. That is, people tend to value goods more if they involve ownership, i.e. they express a preference for a particular reference point, namely the endowment. This contradicts standard theory which says that preferences are invariant with respect to the current endowment. Evidence from [Kahneman et al. \(1990\)](#) is based on dividing students into three groups. One group was given a choice between a mug worth \$4.95 and a chocolate bar worth \$6.00, and 56% chose the mug over the chocolate bar. A second group first got the mug and was then given the opportunity to trade it for the chocolate bar; here, 89% chose to keep their mug. Students in the third group were first given the chocolate bar and then the opportunity to trade it for a mug. 90% chose to keep their chocolate.

Further experimental evidence has identified reference points other than initial endowment, referred to as status quo or default bias. For example, individuals were asked to make a choice about investment options with different risk ratings. It was found that an option became significantly more popular when it was designated as the status quo or default. One other effect worth mentioning is that loss aversion implies asymmetric price elasticities of demand, reflecting the fact that consumers are more sensitive or responsive to price increases (for normal goods) than price cuts ([Kahneman et al. 1991](#); [Caballero 2004](#)).

A main departure from the linear processing of probabilities in expected utility theory is provided by prospect theory, which models individual attitudes toward probabilities with a so-called 'probability weighting function'. It allows for different weights on gains and losses. Useful insights emerge from extensions of prospect theory. [Kahneman and Tversky \(1992\)](#) propose a modification of their original theory, which is sometimes referred to as cumulative prospect theory, using a probability weighting function on probability ranks of outcomes<sup>2</sup> instead of single probabilities. This function is able to accommodate the commonly observed overweighting of extreme events with low probabilities and high consequences. Another

<sup>2</sup> The rank of a positive outcome  $x$ , or good-news probability, is defined as the probability of getting an outcome better than  $x$ .

modification of expected utility theory is prospective reference theory by [Viscusi \(1989\)](#). He suggests that next to expert assessments of risks individual perceptions of risks play an important role in individual decisions. The latter may deviate considerably from risk judgments by experts. Therefore, behavior may be different from what is expected if one would assume a fully rational assessment of risk by individuals. Decisions are made according to a perceived risk which is a function of a prior risk belief and experts risk assessment. The discrepancy between an individual's perceived probability and the actual risk may lead to decision biases. For example, the choice of the level of insurance depends on the perceived risk. Factors that restrain this relationship may decrease the incentive and willingness to protect, i.e. the purchase of insurance. Hence, failure to adequately perceive risks may lead to inadequate precautions or level of insurance. [Viscusi \(1995\)](#) suggest two policy interventions to alleviate such failures. Biases that distort individual decisions can be restrained by altering risk perception through information provision or regulation of risk, e.g. offer mandatory insurance. Risk information and risk control may alter and influence risk perceptions and consequently decisions. Related work on decisions involving risk illustrates the limits of human rationality. [Kunreuther et al. \(1978\)](#) and [Slovic et al. \(1982\)](#) provide empirical evidence documenting such biases with respect to natural disaster, insurance decisions and responses to hazardous activities. They find, for example, that self-protection might be hampered by bounded rationality. [Zeckhauser and Viscusi \(1990\)](#) argue for improved information mechanisms through government interventions to overcome human limitations on individual choices.

Behavioral economics has regularly found preference reversal, also referred to as constructed preferences, which is a violation of procedure invariance. The latter means that certain preferences are invariant with regard to the procedure used to elicit them. Experimental evidence shows that the procedure for eliciting choices affects the order of preference, showing that there are no pre-defined preferences but that these are, in some way, constructed in the elicitation process ([Lichtenstein and Slovic 1971](#); [Tversky and Thaler 1990](#)).

### 2.1.2 Intertemporal Choice

Normative theory proposes the standard discounted utility model, weighting utilities by an exponentially declining discount factor. Exponential discounting yields time-consistent preferences, meaning that individuals act according to their long-run interest when making decisions over time. However, individuals show behavior over time that is inconsistent with this. For example, they regularly show time-inconsistent preferences in decision-making characterized by discount rates varying over time. This means they have distinct preferences over nearby and distant choices, violating the principle of exponential discounting. Instead they employ short-run discount rates which are higher than long-run ones, known as hyperbolic discounting. Such behavior might imply that people make short-sighted decisions when cost and benefits are immediate, referred to as the immediacy effect or myopia choice behavior. This type of behavior has been interpreted as a lack of self-control or present-biased preferences, with choices being dominated by immediate benefits ([Laibson 1997](#); [O'Donoghue and Rabin 1999](#)). This can result, for example, in individuals consuming their savings ([Ashraf et al. 2006](#)), buying addictive products, or showing bad habits such as smoking ([Thaler and Shefrin 1981](#); [Werthenbroch 1998](#); [Frederick et al. 2002](#)). Happiness research ([Frey and Stutzer 2006](#)) supports the role of time-inconsistent preferences by providing empirical evidence that individuals put a heavy weight on the present situation, focus on immediate utility and make inconsistent choices over time. This has immediate policy implications: for instance, whereas standard economic theory predicts that a tax on smoking will reduce not

only one's consumption but also one's well-being, happiness research suggests a positive effect on subjective well-being.

Many instances of economic behavior can be explained by habits, which can be described as well-practiced activities of everyday behavior (Verplanken and Aarts 1999). According to rational choice theory, habits are a type of addictive behavior. Becker and Murphy (1988) propose a model of rational addiction that accounts for past consumption effects. Behavioral economics emphasizes that habitual behavior can be explained by having time inconsistent preferences. Indeed, habit formation is defined as follows: "[...] the more of the product a person has consumed in the past, the more he desires the product now" (O'Donoghue and Rabin 2000: 1). As a result, individuals sometimes make decisions which are not in their best long-run interest. The interaction between habits and choice behavior has also been approached from an evolutionary point of view. This involves concepts like routines, automatic behavior, behavioral lock-in and path dependency (Hodgson 2004).

Other anomalous temporal choice patterns include, among others, the magnitude effect—discount rates for losses being higher than for gains; the sign effect—gains being discounted more than losses; the sequence effect—individuals preferring improving sequences such as an increasing wage profile; and negative time discounting—utility can be derived from the mere anticipation of a future gain. For more effects and details see Loewenstein and Prelec (1992); O'Donoghue and Rabin (2000) and Frederick et al. (2002).

### 2.1.3 Judgment Problems

Behavioral economics proposes that people do not behave rationally in the case of complex and infrequent decision-making. Experiments have assessed that they make use of heuristics in order to reduce complexity in decision-making. In general, heuristics can be quite useful when time and cognitive abilities are limited, but they also can lead to systematic errors of judgment, violating standard statistical laws and Bayes rule. The three most common heuristics in probability judgment are the availability, representativeness and anchoring heuristics.

The availability heuristic describes people's assessment of the probability of an event where the probability of recent instances and events with a relatively large class is overestimated because these are more easily mentally available and imaginable. An example is that the subjective probability of traffic accidents rises temporarily when one sees a car overturned by the side of the road. People using the representativeness heuristic are likely to evaluate probabilities by the degree to which one event is representative of, or resembles, other events. In addition, people judge a frequency by comparing the similarity of the case with the image or stereotype of the class, often to the exclusion of prior probabilities, base-rate frequencies, sample size, and other factors that should affect probability judgments. The anchoring or adjustment heuristic reflects the fact that estimates are heavily biased towards a given starting point or initial value. For example, in an experimental study people being asked to estimate the number of African countries in the United Nations were given an arbitrary number between 0 and 100 (starting point) before their evaluation. Their estimate was reported as being biased towards the assigned arbitrary starting point (Kahneman and Tversky 1974).

The tendency to reach judgments that reflect a self-serving bias, i.e. mixing what is fair with what benefits oneself, presents another behavioral anomaly in decision-making. This is evident in many judgment situations, such as people overestimating their own contribution to joint tasks, people tending to attribute their successes to ability and skill, but their failures to bad luck, and people being likely to arrive at judgments of what is fair or right which are biased on the direction of their own self-interests. Similarly, the optimism bias shows

that people are overconfident about their own relative abilities and unreasonably optimistic about their futures. Overconfidence can explain, for example, a high rate of business failures (Camerer 1999).

Besides violations of probability judgment, behavioral decision theory describes other cognitive anomalies where individual decision-making deviates from rational choice axioms (Rabin 1998; McFadden 1999). Some findings are as follows. Decision anomalies arising from the way individuals process information include: order effects—individuals establish aspiration levels (reference points) and set goals relative to these benchmarks, or are influenced by ethical and superstitious beliefs; primacy (recency) effects—initial (most recent) experiences are more readily recalled than ones in between; focal effects—categorical approximations are used to minimize recall and reporting effort; isolation or cancellation effects—common aspects of alternative lotteries are ignored when they are compared; and segregation effects—riskless components of a lottery are evaluated separately. Choices are also influenced by the context in which they are made. For example, the addition of another option to a choice problem may enhance the attractiveness of the existing options. Information that seems most relevant at the moment may be overemphasized in relation to other information, known as the saliency or prominent effect. The projection effect means that individuals might make judgment errors because their decision is misled by a broader but irrelevant context. And the misinterpretation effect reflects the fact that individuals misinterpret judgments due to a real or perceived strategic advantage.

Next, the concept of mental accounting<sup>3</sup> by Thaler (1980) provides further evidence that consumers act in a manner that is fundamentally inconsistent with standard economic theory. Mental accounting is the activity of individuals or households to organize, evaluate and keep track of their financial activities. People keep mental accounts for different expenses, such as food, clothing, entertainment and education. This violates the standard view that money is fungible, i.e. that any unit of money is can be replaced by another (Thaler 1999).

Recent research has introduced emotions into economic decision-making models. Neuroeconomics has helped in obtaining insights about behavior and explaining visceral influences like emotions or fatigue in decision-making. Neuroeconomics combines economic theory with a broader understanding of the mechanics of the brain. For example, emotions do not necessarily comply with utility maximization rules. It is found that immediate emotions, i.e. affectiveness or feeling which is unrelated to the decision at hand, can have a significant impact on choice. An example of the emotional influence on decision-making is that due to current arousal people make decisions they will regret later on (Loewenstein and Lerner 2003).

## 2.2 Limited Self-Interest

Standard economic theory on which environmental policy theory is based assumes that economic behavior is explained by people pursuing only self-interest. Any other-regarding preferences are excluded. People holding other-regarding preferences value outcomes of other people either positively or negatively (Camerer and Fehr 2006). For example, people voting or making voluntary contributions to public goods, such as blood donations and voluntary collection and recycling of waste, cannot be explained solely by pure self-interest. Behavioral

<sup>3</sup> The idea that choices are altered through the introduction of boundaries, named choice bracketing is a related concept. It describes the grouping of individual choices together into sets (Read et al. 1999). Similarly, rule-driven behavior is described by McFadden (1999, 85) as judgment being "...guided by principles, analogies, and exemplars rather than utilitarian calculus". For example, people develop rules for money, so-called accounts, applying to living or food expenses.

economics suggests that the individual utility function has to be modified to take account of two types of other-regarding preferences: (1) non-selfish motives or social preferences, such as fairness, reciprocity, altruism and intrinsic motivations; and (2) self-identity concerns, such as reputation, self-respect and status. Several studies have examined how economic behavior is influenced by other-regarding preferences (Andreoni 1989; Rabin 1993; Frey 1997; Lindbeck 1997; Fehr and Schmidt 1999; Bénabou and Tirole 2003).

An important line of experimental research suggests that fairness motives affect people's behavior. Fairness is generally defined as people caring about equitable outcomes and is also referred to as inequality aversion, which denotes the fact that people prefer equal distributions of payoffs (Smith 1991; Fehr and Schmidt 1999). Experimental games, such as ultimatum and public goods games, have shown that people hold preferences which depart from pure self-interest. In particular, people care for equitable outcomes and behave fairly and cooperatively in many situations where the self-interest model would predict complete defection. Kahneman et al. (1986) document that consumers' strong sense of the fairness of a firm's pricing decisions can explain why monopolists have to set the price below the price predicted by theory, and thus cannot fully exploit their monopoly power. Some studies have combined ethnographic and experimental approaches to provide cross-cultural evidence for fairness preferences in the field (Heinrich et al. 2001).

Experimental evidence supports another type of social preference, namely reciprocal behavior (Fehr and Gächter 2004). Reciprocity means that, in response to friendly actions, people frequently react more cooperatively than suggested by standard theory. Likewise, negative reciprocity also exists, i.e. people respond non-cooperatively to hostile actions (Rabin 1993; Falk and Fischbacher 2006). Research has shown that reciprocity can have important economic implications in areas like work motivation and contract enforcement (Fehr and Gächter 2000). Falk (2004) extends findings on reciprocity by using field data to assess motives behind charitable giving. Related to reciprocity is the concept of conditional cooperation, asserting that people cooperate if others cooperate too. For instance, pro-social behavior is conditional on other people's cooperative behavior. In particular, the persistence of such behavior has been explored in the context of social dilemmas or collective action problems, such as tax compliance, common pool resource use, democracy and "not in my backyard" situations (Ostrom 1998; Karp 2005).

Altruism means that individuals help others while making sacrifices. Altruistic traits can have important consequences for economic behavior in the family and work place (Simon 1992). Andreoni (1989, 1990) suggested that people derive utility from the act of giving, labeled the "warm glow effect". This model of human behavior is also referred to as impure altruism. In addition, studies document heterogeneity in altruistic behavior. Besides pure and impure (utilitarian) altruism, a third type is encountered, namely people undertaking altruistic or pro-social activities in order to improve their self-image. However, this may mean they do not care as much about the outcome of their pro-social behavior as they do about the way their behavior affects their self-identity. In order to self-signal reputation or status, people undertake activities such as conforming to social norms (Bénabou and Tirole 2006).

An agent's consumption behavior is best understood within a social context, as it is shaped by imitation, comparison with and learning from others, and status effects (Heinrich and Boyd 1998). Happiness research has provided strong evidence that welfare is affected by many factors other than income and consumption, including status (Postlewaite 1998; Weiss and Fershtman 1998; Easterlin 2001; Frank 2005a). Social status relates to the relative position of an individual in a society and can be expressed in many forms: social recognition, self-respect, honor, esteem, social standing, and prestige. Individuals strive not only for material reward in terms of money payoffs but also for social rewards. For example, a car might not



only be bought for its use value but also to attain status. [Veblen \(1899\)](#) already noted the function of consumption in attaining social status and power. Consumption displays not only one's income and wealth to others but also one's position in society. In his seminal contribution [Duesenberry \(1949\)](#) acknowledged that relative income determines the consumption and saving patterns of households. [Brekke and Howarth \(2000\)](#) note the symbolic meaning of goods, stating that commodities may serve to communicate one's self-image to others or reinforce it.

Many of these ideas relate to evidence that, in various cases, people behave as if they were intrinsically motivated rather than stimulated by any financial reward (material self-interest), as suggested by standard economic theory. For policy, there is supporting experimental evidence on the conflict between external incentives (rewards or punishment) and intrinsic motivation. [Deci \(1972\)](#) reported that, in order to increase the intrinsic motivations of children, employees or students, policy makers should beware of concentrating on external incentives, like monetary rewards, because they can decrease such motivations. Experimental and field evidence has confirmed that external incentives can crowd out intrinsic motivations ([Frey 1997](#); [Bénabou and Tirole 2003](#)), sometimes referred to as moral motivations ([Brekke et al. 2003](#)). For example, increased pay for workers can undermine their intrinsic motivation to work. Another example provided by [Gneezy and Rustichini \(2000\)](#) shows the effect of monetary incentives on stimulating parents to pick their children up on time. It is found that a monetary punishment leads to the reverse of intended effect—parents arrive even later. [Carpenter and Myers \(2007\)](#), using data on volunteer firefighters, find that pro-social behavior can be crowded out by extrinsic monetary incentives. [Frey and Jegen \(2001\)](#) review other evidence.

The effect of non-pecuniary incentives on pro-social behavior has received relatively little attention in economic policy analysis. Extrinsic incentives in the form of social approval, ostracism, or public embarrassment can serve as a punishment or reward to stimulate certain types of behavior. Such social incentives operate through feelings of status, esteem, pride or fear. Concrete channels to implement them are public disclosure and awards or prizes. For example, [Frey and Neckermann \(2008\)](#) have studied social awards in the form of public recognition as a mechanism to improve cooperation in a work place setting. They point out that the main difference with monetary compensation is that awards stimulate social recognition and social reinforcement and so are less likely to crowd out intrinsic motivations. In addition, incentives in the form of awards have a long term effect in the sense that they create role models and thus distribute information about desirable behavior. Another example showing the positive effect of non-pecuniary incentives on fostering altruistic behavior is an experimental study by [Ellingsen and Johannesson \(2008\)](#). They illustrate that anticipated verbal rewards and punishments in the form of written feedback induce a higher rate of altruistic behavior. Positive feedback result from symbolic rewards evoking feelings of pride, while negative feedback is due to symbolic punishment causing feelings of shame which individuals tend to avoid.

In addition to looking at the separate effect of immaterial punishment or rewards, some studies have examined their interaction with material incentives. For example, [Noussair and Tucker \(2005\)](#) find that contributions to a public good are higher when material and informal punishment mechanisms are applied in combination than when only one of the two forms of punishment is used. An empirical example of using social incentives for rule enforcement is the implementation of a public embarrassment mechanism in the form of a public mocking campaign in the city of Bogota to endorse compliance with traffic laws. In order to promote rule compliance by individuals, the public administration made use of mimes in the city's streets to shame traffic violators. This type of public disclosure of citizen behavior makes use of peoples' aversion to be disapproved or shamed in front of others ([Caballero 2004](#)).

### 3 Heterogeneity, Evolution and Happiness

This section is intended to broaden the picture somewhat, focusing on three interrelated themes. It will not offer a full review of all relevant issues associated with each theme. This would require a book format. Instead, we want to clarify the way in which the translation of rather abstract and isolated insights from behavioral economics to policy can be made more relevant, complete and effective.

Standard economic theory generally assumes representative agents, even though a population of heterogeneous agents is more typical of reality. People show varying degrees of bounded rationality, and self- versus other-regarding preferences (Andreoni and Miller 2002). For instance, Fischbacher and Gächter (2006), performing a public good experiment, find heterogeneity of social preferences. An important implication of the existence of heterogeneity is interaction between these different agents. For example, other-regarding individuals can generate a cooperative outcome if they provide incentives for selfish individuals to behave pro-socially. Likewise, self-interested individual can trigger non-cooperative behavior. Thus, the interaction of heterogeneous preferences of individuals may affect the aggregate outcome (Camerer and Fehr 2006; Gächter 2006). Therefore, taking multiple, heterogeneous individuals into account can lead to a better and more realistic view of behavior and prediction of outcomes. Also, in order to specify a complete model of relative positions, status, imitation and information diffusion, the representative agent model needs to be replaced by a model of interaction between multiple, similar but heterogeneous agents. This implies an evolutionary approach in which selection and innovation interact to change the diversity of behaviors. Such an evolutionary view of economic behavior and interaction has various implications for public policy (van den Bergh and Kallis 2009).

Findings from evolutionary psychology can enhance our understanding of how preferences, beliefs and rationality are shaped (Robson 2002). Recently, Robson (2001), Robson (2002) has written on the biological basis of economic behavior. He argues, much in line with evolutionary psychology, that our behavior was shaped during millions of years living in small hunter-gatherer groups. This might imply that our behavior is inappropriate for, or at least not well adapted to, current circumstances, including the objectives of sustainable consumption and development (Jackson 2000; Siebenhüner 2000). Robson make some interesting points. Fitness suggests that relative success is more important than absolute success, which can translate to interdependent preferences and relative welfare. The evolutionary explanation of human intelligence as resulting from strategic, social interactions—through runaway selection, or an arms race of rational features—seems to have created a much greater capacity for rational behavior in social contexts than in abstract or laboratory situations. This can be explained by the evolution of a ‘theory of mind’ or advanced form of empathy. This, in turn, raises some doubt over findings by experimental economics and is somewhat supportive of rationality. Robson argues that by considering the two hypotheses—ecological (evolution in response to environment or other species)—and social—explaining the evolution of human intelligence—more can be understood about the limits and anomalies of human intelligence.

Besides experiments, happiness research has contributed considerably to a better understanding of the determinants of behavior and subjective well-being (Frey and Stutzer 2002). It allows for evaluating the effects of cognitive biases or social motives on well-being. Whereas standard economics regards certain types of behavior as welfare-decreasing, using an abstract formulation of welfare, from the point of view of subjective well-being there often is no clear loss of welfare. For instance, Meier (2007) finds that other-regarding behavior like volunteering can contribute positively to well-being. Happiness research can also help to assess whether individuals make systematic errors in consumption decisions, i.e. not showing



utility-maximizing behavior. For instance, [Stutzer and Frey \(2006\)](#) document empirical findings on subjective well-being suggesting that self-control problems, such as smoking, influence life satisfaction. Last but not least, happiness research assesses the heterogeneity of individuals' preferences, which can serve as input for modeling heterogeneity in populations of interactive agents as outlined above.

#### 4 Implications of Behavioral Economics for Individual Decision-Making and the Environment

An integration of psychology and economics as in behavioral economics can lead to better predictions of economic behavior and, subsequently, to better policy descriptions ([Camerer 1999](#)). Limitations to rationality and self-interest in individual decision-making mean that certain policies will not be as effective and efficient as predicted by standard theory. Below, we will translate insights from behavioral economics to the context of individual environmental decision making.

Table 2 lists important behavioral findings, associated behavioral theories, and their consequences for environmental economics. The assessment is based on a review of relevant theoretical, empirical and experimental studies covering four important areas relating to environmental policy where individual behavior and decision-making matter: environmental valuation, sustainable consumption, policy design, and the particular and the topical case of climate change policy. This section and Sect. 5 present details for each of these areas.

##### 4.1 Pro-Environmental Behavior, Consumption and the Environment

Consumers make choices in a number of domains that have environmental impacts. They buy products, use water and energy, and discard waste. Standard neoclassical-economic analysis focuses on policy that emphasizes the impact of income and prices on behavior. As we have seen in previous sections, this, however, does not represent a correct and complete picture of individual behavior. Bounded rationality and factors other than price and income, such as loss aversion, social interactions, imitation and status, determine consumer preferences. A behavioral approach to the analysis of consumer behavior acknowledges the limits to rationality and self-interest. It also needs to account for psychological factors ([van den Bergh 2008](#)).

The important role of bounded rationality in individual decisions on energy use and conservation is supported by many studies ([van Raaij and Verhallen 1983](#); [Stern 1992](#); [Faiers et al. 2007](#)). A well-known finding is the energy-efficiency paradox. It refers to the persistence of a gap between current and optimal (cost-effective) energy use and thus conservation. The literature suggests market failures are the main cause of the slow spread of energy efficiency. Examples of such barriers include adaptation, lack of public concern for energy issues and limited information ([Jaffe and Stavins 1994](#); [Levine et al. 1995](#)). In addition, behavioral anomalies, such as risk aversion, inertia or routines and habits, affect energy use ([Rohdin et al. 2007](#); [Wilson and Dowlatabadi 2007](#)). Prospect theory has been used to study household switching behavior in electricity markets ([Defeuille 2009](#); [Ek and Söderholm 2008a](#); [Juliosson et al. 2007](#)). This includes addressing behavioral anomalies like loss aversion, default bias and the status quo effect as possible explanations for consumer behavior. [Ek and Söderholm \(2008a\)](#) find empirical evidence that the choice of households to switch to other service providers is influenced by a status quo effect. [Pichert and Katsikopoulos \(2008\)](#) offer an experimental analysis of consumer decision-making relating to green electricity use.

**Table 2** Studies on the interface between behavioral and environmental economics

| Environmental domain    | Subtheme                  | Behavioral theory  | Behavioral anomalies and social motives  | Relevant insights   |
|-------------------------|---------------------------|--|--|---|
| Environmental valuation | Non-market valuation      | Prospect theory<br>Heuristics<br>Other-regarding preferences | Loss aversion<br>Endowment effect<br>Status quo<br><br>Ordering effect<br>Lexicographic preferences<br>Warm glow<br>Intrinsic motivation | One explanation for repeatedly reported differences between WTP and WTA values in contingent valuation studies is bounded rationality.  |
| Sustainable consumption | Energy<br>Travel<br>Waste | Prospect theory  | Status quo<br>Loss aversion<br>Default bias  | Value of consumer choices in monetary terms is influenced by inertia (status quo), loss aversion and default bias, which effectively means that cost savings are neglected.   |
|                         |                           | Time-inconsistent preferences                                | Habits   | To promote pro-environmental behavior, green alternatives should be presented as the default option to the consumers.<br>Many environmentally significant behaviors have a habitual character. Habits play a key role in many energy consumption activities.<br>The formation of good habits may be encouraged by monetary incentives. If intrinsic motivation is strong, such incentives can be counterproductive. Instead, other policies like “deliberation intervention” can work better. |
|                         |                           | Other-regarding preferences                                  | Altruism (warm glow)<br>Intrinsic (moral) motivation<br>Self-identity (conformity)   | Households having greater concern for the environment or stronger altruistic attitudes (warm glow) are more sensitive to participation and early adoption of green alternatives.  |

Table 2 continued

| Environmental domain | Subtheme                     | Behavioral theory   | Behavioral anomalies and social motives                                   | Relevant insights   |
|----------------------|------------------------------|---|---|---|
| Policy design        | Regulatory choice and design | Prospect theory<br>Heuristics<br>Time inconsistent preferences<br>Other regarding preferences | Endowment effect<br>Status quo<br>Framing<br>Habits<br>Status<br>Altruism | Marketing efforts through environmental and charitable organization as well as concentrated and repeated information provision to households can increase participation rates.<br>Social motives and self-image concerns (e.g. buying/showing less environmentally damaging products/behaviors) generate utility.<br>Moral motives can lower the cost of environmental activities like waste sorting.<br>Influencing beliefs and expectations about others' behavior can impact green consumer behavior (e.g. adoption of green electricity). |
|                      |                              |   |   | Social motives are positively correlated with pro-environmental behavior and lead to cooperation in social dilemmas.  |
|                      |                              |   |   | External regulations (e.g., financial incentives) can crowd out social preferences.   |
| Policy design        | Regulatory choice and design | Prospect theory<br>Heuristics<br>Time inconsistent preferences<br>Other regarding preferences | Endowment effect<br>Status quo<br>Framing<br>Habits<br>Status<br>Altruism | Social rewards and punishment can be an option to increase cooperative behavior. For example, social approval, e.g. identity revelation, can increase voluntary contributions to a public good.   |
|                      |                              |   |   | Market-based instruments like emissions trading might not work efficiently.   |
|                      |                              |   |   | Policy instruments might not look attractive to policy makers, public officers, the business community or the general public due to framing effects.<br>Market-based instruments might be framed as giving a "right to pollute" rather than taking it away from polluters, meaning a framing as an environmental loss.  |

Table 2 continued

| Environmental domain | Subtheme             | Behavioral theory             | Behavioral anomalies and social motives   | Relevant insights   |
|----------------------|----------------------|-------------------------------|---|---|
| Climate change       | Risk                 | Prospect theory Heuristics    | Status quo, myopic behavior, optimistic bias, ambiguity aversion, availability and representativeness heuristic | Status-seeking and habits raise the level of efficient consumption and income tax rates.<br>Social preferences can affect optimal Pigovian taxation.<br>Small-probability high-impact scenarios are better captured by prospect theory.<br>Participatory processes can overcome decision heuristics leading to inadequate policy enforcement. |
|                      | Discounting          | Time-inconsistent preferences | Hyperbolic discounting Framing  | Long-run environmental problems are sensitive to the assumed discounting pattern or method.<br>Spatial and time frame are important for the communication of climate-related information  |
|                      | Negotiation          | Other-regarding preferences   | Social preferences  | Social preferences can lead to voluntary environmentally responsible behavior.  |
|                      | Cooperative behavior |                               |   | Social punishment and reward mechanisms set in place can be useful for climate change policy negotiations and voluntary emissions reduction.  |

They examine peoples' motivation for choosing green electricity in a laboratory experiments and find that default options have a strong influence on consumer choice. A policy lesson drawn is that, in order to promote pro-environmental behavior, green electricity should be presented as the default option for consumers. A more theoretical study of adoption, consumption and green products is [Janssen and Jager \(2002\)](#).

Another strand of research examines time-inconsistent preferences, considering the role of habits and routines in (un)sustainable consumption ([Jackson 2005](#); [Stern 2000](#)). This mainly deals with two particular domains, namely energy use and transport issues. A fairly extensive literature in psychology addresses habitual car use behavior ([Gärling and Axhausen 2003](#); [Verplanken and Aarts 1999](#)). In addition, experimental studies have been devoted to examining the context of habits and travel choice behavior. For instance, using data from a field experiment in Sweden, [Eriksson et al. \(2008\)](#) argue that habitual behavior appears as a key factor in choosing means of transport. A reduction in car use may be facilitated by interrupting habitual car use by means of a so-called "deliberation intervention", in particular if the car user has both a strong car habit and a strong moral motivation to reduce personal car use ([Carrus et al. 2008](#)). With regard to energy consumption, habits have served as an explanation for the efficiency paradox mentioned above ([Marechal 2009](#); [Schleich and Gruber 2008](#)). Empirical studies also demonstrate how to direct energy saving choices in the presence of habits ([Stern 1992](#); [Barr et al. 2005](#)). One policy lesson is that a behavioral change in lifestyles fostering energy saving might be facilitated by promotional techniques like the provision of information in various ways ([Abrahamse et al. 2005](#)).

Standard analysis sees pro-environmental behavior, i.e. voluntary contributions to a public environmental good or natural resource, within the context of social dilemmas. Traditionally, the private provision of a public good fails due to its characteristic of being non-rival and non-excludable. Selfish individuals have no incentive to contribute, and may free ride on its provision. However, from a behavioral economics perspective, concerns about social preferences and self-identity can lead to voluntary contributions to an environmental public good. Not only are these motivations important for purely social dilemmas but they may generally influence consumer decisions about buying and using goods and services (with environmental impacts).

Studies assessing additional motives for behavior use empirical data on household energy use ([Clark et al. 2003](#); [Menges et al. 2005](#); [Kotchen and Moore 2007](#)) or recycling activities ([Ackerman 1997](#); [Berglund 2006](#)). For instance, [Kotchen and Moore \(2007\)](#) analyze the motivation of households to participate in green electricity programs using empirical data from the US. Presenting a theoretical framework which covers different participation mechanisms for green electricity programs, their results show that households which have a greater concern for the environment or stronger altruistic attitudes are more likely to adopt green electricity. Similarly, [Clark et al. \(2003\)](#), in a study of Dutch households, investigate the influence of internal (altruism) and external variables (demographics) on household participation in green electricity programs. They also find that a high intrinsic motivation and values like altruism may explain early adoption of green electricity. Another study by [Menges et al. \(2005\)](#) is worth mentioning. It performs an experiment instead of an empirical analysis to test for the presence of "warm glow" motivation when adopting green electricity programs. The authors conclude that people receive benefits from solely contributing to environmental quality when participating in a green electricity program. Recycling and waste disposal at household level is costly, i.e. messy and time consuming. Households might not be aware of the social benefits gained through proper waste management because they are hardly noticeable, which makes free riding more likely. Individual moral and social motives for recycling activities are important determinants of people's willingness to pay for sorting waste. These

motivations significantly lower the costs associated with household recycling efforts which will affect the adequate regulatory policy. [Brekke et al. \(2007\)](#) analyze recycling of household waste as a prime example of voluntary contribution to a public good, since collecting and recycling are costly and any environmental benefits resulting have a clear public good character, i.e. are non-rival and non-excludable, and are hardly noticeable to the household itself. In an empirical study conducted in Norway it is found that civic duty orientation is an important motive for recycling behavior. [Ackerman \(1997\)](#) found that altruistic considerations dominate in collection and recycling efforts undertaken by households. Similarly, [Berglund \(2006\)](#) shows that people may derive positive “warm glow” feelings by contributing to a better environment through recycling. [Halvorsen \(2008\)](#) uses empirical data on recycling activities by Norwegian households to study how social and moral norms affect their utility. Norm-based incentives like feelings of self-respect and “warm glow” turn out to contribute significantly to recycling efforts.

Some studies include psychological factors like status or behavior by others in their analysis of environmentally relevant behavior. [Ek and Söderholm \(2008b\)](#) do this in a study of electricity use, and [Johansson-Stenman and Martinsson \(2006\)](#) in a study of car purchase. The latter study acknowledges that the status effect is difficult to disentangle using consumption data for goods and thus it is not always clear how important status is when making consumption decisions. Ek and Söderholm find that a choice between green and other electricity is determined not only by economic factors but also by the presence of status behavior and relative positions. Their analysis shows that self-image is affected not only by the behavior of others but also by the purchase of green goods. Such findings are in line with [Bénabou and Tirole \(2006\)](#) who suggest that people undertake activities to highlight their good traits, such as pro-social activities, in particular pro-environmental behavior.

Experimental evidence from common-pool resource and public good games supports the influence of, amongst others, reciprocity, fairness, social norms and self-identity concerns within the framework of social dilemmas. Behavioral economics suggests that the establishment of conditions under which people cooperate and show reciprocity behavior can solve social dilemmas ([Fleishman 1988](#); [Ostrom 1990](#); [Brown and Stewart 1998](#)). In particular, field experiments associated with common-pool resources such as fisheries and forests confirm the importance of these issues in natural settings ([Velez et al. 2009](#); [Cardenas et al. 2000](#); [Cardenas and Ostrom 2004](#); [Rodríguez-Sickert et al. 2008](#)). Other examples are reciprocal behaviors found in the context of blood donations ([Titmuss 1970](#)), contributions to a social fund ([Frey and Meier 2004](#)), and employment relations ([Gneezy and List 2006](#)) (see also Sect. 2.2). Only a few natural field experiments investigate the role of reciprocity within a specific environmental context. For example, [Alpizar et al. \(2008\)](#) offer an analysis of the importance of reciprocity for voluntary contributions to a national park in Costa Rica using a natural field experiment. They find that reciprocity behavior induces more people to contribute financially to the park. Their results highlight that information about the determinants of voluntary contributions can assist in the design of strategies and policies aimed at increasing contributions to the financing of public goods. [Biel and Thøgersen \(2007\)](#) review motivations for submitting to environmental compliance, like social norms supporting cooperation behavior.

#### 4.2 Environmental Valuation and Individual Decision-Making

There is a considerable literature on the monetary valuation of environmental goods. Two important reasons for undertaking valuation research are to inform policy makers about the value of non-market goods and the size of environmental externalities. Several studies

have connected valuation research approaches or outcomes to behavioral economics. This involves examining responses to contingent valuation surveys, including potential psychological biases and social preferences. For example, experimental evidence reported by [Kahneman et al. \(1990\)](#) supports the endowment effect, a decision anomaly of expected utility theory, as a reason for response behavior in valuation studies. Here, a reference position shapes preferences, that is, the value of a good is affected by ownership. Evidence for the importance of other-regarding preferences is provided by [Kahneman and Knetsch \(1992\)](#) who found that an individual's contribution to a public good makes them feel good, something they referred to as "purchase of moral satisfaction", leading to a gap between stated willingness to pay and real economic preferences.

The role of preference anomalies in contingent valuation studies and other preference elicitation methods questions the validity of cost-benefit analysis to inform public policy. If revealed preferences deviate from rational choice theory, then cost-benefit analysis using results from monetary valuation studies, which assume rational agents, might be misleading. In order to assure robust results from cost-benefit analysis it is suggested to either "uncouple" cost-benefit analysis from the assumption of preference coherence ([Sugden 2005](#))<sup>4</sup> or incorporate "suitable controls" for the type of errors that may arise ([Braga and Starmer 2005](#)). Neither of these proposals, however, seems to have been very well elaborated yet. A more radical alternative is rejecting cost benefit analysis and replacing it by multi-criteria analysis or participatory approaches (see for example, [Munda 2004](#)). These evidently are not free of criticism either.

We do not offer further details here as unlike the other intersections of behavioral and environmental economics, this one has been covered quite well in recent reviews. [Johansson-Stenman \(2002\)](#) and [Hanley and Shogren \(2005\)](#) provide surveys of the evidence of anomalies and their impact on preference elicitation methods and cost-benefit analysis. For a summary of field data on preference inconsistencies and their impact on US policy makers see [List \(2005\)](#).

## 5 Implications of Bounded Rationality and Limited Self-Interest for Environmental Policy Theory

Several authors have attempted to use alternative models of individual behavior to provide a foundation for the theory (or theories) of environmental policy and institutions ([Ostrom 1990](#); [Sanstad and Howarth 1994](#); [Norton et al. 1998](#); [van den Bergh et al. 2000](#); [Shogren 2002](#); [Vatn 2005](#)). Early experiments in environmental economics on environmental valuation, public goods and the Coase theorem ([Bohm 1972](#); [Hoffman and Spitzer 1982](#); [Brookshire et al. 1990](#)), as well as more recent research ([List 2006](#); [Shogren and Taylor 2008](#)), explore specific behavioral anomalies in relation to environmental policy.

We consider environmental policy under a range of behavioral assumptions, consistent with findings of behavioral economics as documented in previous sections. Inspired by [Hahn \(1989\)](#), who investigated whether the patient (environmental policy) followed the doctor's advice, this paper aims to examine if the doctor (environmental economics) is prescribing the right medicine (i.e. using correct behavioral assumptions).

<sup>4</sup> [Sugden \(2009\)](#) concludes that values based on hedonic prices may be less susceptible to WTA/WTP disparities than values obtained with stated-preference methods.

### 5.1 General Policy Insights

This section addresses the question of the implications that observed bounded rationality and other-regarding behavior have for the design of environmental policy. Only a few studies have devoted explicit attention to this. [Shogren and Taylor \(2008\)](#) define a new, behavioral environmental second-best problem. That is, they regard bounded rationality as a type of market failure which needs correction through public policy. Environmental policies should thus be considered to correct not only for traditional market failures but also for behavioral or rationality failures. Environmental policy should, then, generally be designed in such a way that it corrects for both market failures (environmental externalities) and behavioral failures. For example, regarding firm behavior, [Venkatachalam \(2008\)](#) notes that status quo bias can explain lobbying activities by polluting companies. They prefer the present situation and prefer to stick to inefficient command-and-control policies instead of having their emissions controlled through more efficient, market-based instruments. These observations imply a less optimistic view of efficient policy than neoclassical economics.

Inconsistencies and biases due to heuristics in individual decision-making can lead to inconsistent evaluation of public policy. In particular, framing effects are relevant for the evaluation of tax policy ([McCaffery and Baron 2006](#)). [Nash \(2006\)](#) analyzes the effect of framing on environmental policy choice by the policy-maker, and indirectly by society and its various stakeholder groups (consumers, voters, business community, environmental NGOs). He finds that framing effects affect public perception of and reaction to the choice of command-and-control policies over market-based instruments. For example, market-based instruments give the “right to pollute” rather than take it away from polluters (i.e. before regulation they implicitly had a right to pollute). This means they are framed as creating an environmental loss. In order to reduce such biases, he suggests educational measures or changes in the way a regulatory instrument is framed. For instance, when framing a tradable permit system, permits might be referred to as “emission penalty” rather than “right to pollute”. [Löfgren and Nordblom \(2006\)](#) present a formal analysis answering the question how consumption of a habitual good, which causes a negative external effect on the environment, affects environmental taxation. They find that the magnitude of tax rates is affected by habit formation. A stronger habit tends to increase consumption, so the optimal correcting tax should also be increased. [Johansson \(1997\)](#) analyses behavior driven by social preferences and environmental taxation. More specifically, he studies the effects of different kinds of altruistic behavior on the design of a Pigovian tax to correct for an externality. He finds that altruism affects the size of the tax.

Theoretical studies have examined the environmental regulation of household consumption behavior in the presence of status effects and relative positions ([Hirsch 1976](#); [Howarth 1996](#); [Brekke and Howarth 2000](#); [Brekke et al. 2002](#)). [Howarth \(1996\)](#) presents a theoretical analysis of the relationship between status, consumption levels and environmental degradation. He modifies preferences by incorporating status effects into a standard model of pollution. Status has a positive effect on consumption. In order to arrive at a social optimum, consumption taxes are needed in addition to environmental taxes. For environmental policy, this really means that Pigovian taxes should be adjusted upwards in the presence of status effects (see also [Wender 2005](#)). [Brekke et al. \(2002\)](#) evaluate the [Hirsch \(1976\)](#) hypothesis, i.e. status seeking increases consumption at the cost of environmental degradation. They conclude that this only holds true when status is defined as the difference between one’s individual consumption and the average consumption of society, and if status and non-status goods are poor substitutes.



**Table 3** Change in performance of environmental policy when behavioral theories are accounted for

|                             | Efficiency | Effectiveness | Equity |
|-----------------------------|------------|---------------|--------|
| Risk and uncertainty        | +          | +             | 0/+    |
| Intertemporal choice        | +          | 0/+           | 0/+    |
| Judgment                    | ++         | ++            | 0/+    |
| Other-regarding preferences | 0/+        | 0/+           | +      |

*Note:* signs denote changes relative to (policy under) traditional theory with rational, self-regarding agents (“+” better performance, “++” much better performance and “0” about equal performance)

Standard criteria for policy instrument selection are economic efficiency, effectiveness and equity. Behavioral failures and other-regarding behavior will affect the performance of environmental policy instruments on these three criteria. This is qualitatively assessed in Table 3, by combining the four types of behavioral features discussed in Sect. 2 with the three policy performance criteria. Although it is not possible to make definite statements in this respect, due to a lack of systematic research on policy performance under bounded rationality and other-regarding behavior, a few general speculations can be offered here. Generally, performance in terms of efficiency and effectiveness can be expected to be weaker under bounded rather than perfect rationality. For example, economic policy instruments are based on the assumption that desirable changes in behavior can be achieved by providing monetary incentives. But if agents are boundedly rational or act in accordance with social motives, economic incentives may have not the intended effect on behavior, reducing policy effectiveness. Moreover, if individuals are not reaching their individual optimum or efficient outcome due to bounded rationality, society as a whole is unlikely to arrive at a socially optimal outcome. On the other hand, institutions and policy instruments that stimulate social preferences like reciprocal behavior might improve the effectiveness of policy. It is difficult to make general statements about the equity implications of policy under bounded rationality and other-regarding preferences. One possible effect is that other-regarding preferences imply that individuals may be more concerned with equity and fairness. This in turn can lead to individual outcomes (in terms of welfare or utility) under environmental regulation being more in line with one another than without such inequity-averse preferences. A more equitable welfare distribution may then result. This holds even more so if the policy is designed to recognize and reflect these preferences.

Bounded rationality in an intertemporal choice setting, in particular hyperbolic discounting, means that long-run outcomes receive greater weight, which can stimulate more equal intertemporal welfare distribution. The same result might hold true for decisions in line with Prospect theory regarding long-run impacts of environmental change characterized by small-chance/high-impact scenarios. Judgment biases might have little effect on equity or a small positive effect if they result in less perfect, selfish decisions, so that the outcome is a less polarized welfare distribution, i.e. a move to the mean. Note that in the table we assess judgment biases as having a relatively severe impact on policy performance with regard to efficiency and effectiveness, because these biases basically affect every decision being made by individuals and because there are so many judgment biases around. This is not to deny that in a long-run context climate change and policy performance might be more severely affected by boundedly rational decision-making related to risk and uncertainty and intertemporal choice. Finally, the combination of various behavioral features like those listed in the first column of Table 3 may mean not just an addition of specific effects on policy performance, but possibly

a synergy. For example, judgment biases combined with intertemporal choice may mean that the policy performance comes out worse in terms of efficiency and effectiveness than one would estimate based on adding performance failures for each separately.

Behavioral research can inform consumer policy, accounting for cognitive biases and decision heuristics behind household decision-making. Consumers often do not react to price signals and do not take into account future (energy) costs because decisions are influenced by various biases. Alternatives to price-based regulation are as follows. To promote switching and pro-environmental behavior, green electricity should be presented as the default option to consumers and information cost should be lowered, e.g. through standardized electricity bills. [van den Bergh \(2008\)](#) proposes many alternatives to price-based policies which might be effective under bounded rationality: technical and product-use standards, communicative instruments (education, public awareness campaigns, providing information) and making green alternatives like renewable energy, waste collection and “green products” more easily accessible or available to consumers. In general, better information and educational measures can have a positive effect on sustainable consumption behavior ([Abrahamse et al. 2005](#)). For example, concerning the adoption of green energy [Ozaki \(2009\)](#) finds that social information may be more important and successful than traditional regulation in informing consumer choices about innovative green products as these link up with identity and self-image attributes. This suggests communication of the benefits of adoption at an emotional and social level, where the latter relates to phenomena like comparison, imitation and status seeking. For diffusion of green products it is important to offer clear messages and create social norms and a critical mass through different types of communication channels. Insights from social marketing to encourage pro-environmental behavior may be useful here. Interventions by means of paternalistic-type policies can help boundedly rational consumers to make better decisions ([Camerer et al. 2003](#)). Examples of such policies are food content labels, warnings on cigarette packs or mandatory retirement savings. Although such policies may be seen as inconsistent with consumer sovereignty, they seem legitimate if consumer preferences are inconsistent with long-run sustainability ([Norton et al. 1998](#)).

Experimental studies of time preferences, habit formation, and self-control problems provide useful information about the effectiveness of different policies on quitting and changing habits, or even creating new ones. Examples can be found for health-related behavior ([Gneezy and Rustichini 2000](#); [Hammar and Carlsson 2001](#); [Charness and Gneezy 2008](#)). Using experiments [Charness and Gneezy \(2008\)](#) perform a test of the effectiveness of different policy interventions to encourage the development of a good habit, such as going to the gym or quitting smoking. In particular, the effect of monetary incentives on fostering good habits or stopping bad habits is found to substantially increase the probability of stopping a bad, or starting a good habit. However, intrinsic motivations can potentially alleviate the effect of the intervention, as in some situations economic incentives can discourage such preferences (see Sect. 2.2.).

Recent research stresses the importance of other-regarding preferences, like reciprocity, fairness, altruism and self-identity, for pro-social behavior. Social norms imply social rewards instead of behavior motivated by monetary incentives. This includes norms in favor of work habits or voluntary behavior. Some of the insights have relevance for environmental policy. For example, the principle of inequality aversion, which predicts that people dislike inequality, can be important for various policy issues, ranging from tax morals to environmental negotiations (see Sect. 6.2). In addition, the presence of reciprocity behavior can increase the effectiveness of policy. [Alpizar et al. \(2008\)](#) provide experimental evidence that if people receive a small gift before having to decide about contributing to a public good, this increases the number of people making a positive contribution. On the other hand those individuals

who would contribute without a gift are relatively unaffected. Stimulating the social norm of reciprocity may improve the effectiveness of policy, i.e. increase the number of donations. Other insights emerge from compliance with norms shaped by whether one's behavior is publicly shaped or self-determined. For instance, [Bénabou and Tirole \(2006\)](#) identify image-related rewards or punishment, like concerns for social reputation and self-image, as important drivers of pro-social behavior. A public good experiment conducted by [Rege and Telle \(2004\)](#) shows that social approval can considerably increase voluntary contributions to a public good. The authors suggest identity-revelation as a relevant policy for increasing cooperation.

From a policy perspective, the crowding-out effect of other-regarding behavior has important implications for the provision of public goods and management of natural resources. Several experimental studies have been conducted to provide evidence of the way that external interventions can undermine natural resource conservation ([Ostrom et al. 1994](#)). Crowding-out is not only limited to monetary incentives but also may result from rule enforcement, i.e. exogenously (externally) vs. endogenously (through self-organization) enforced ([Bowles 2008](#)). These categories link to formal and informal regulation, respectively. For example, [Cardenas et al. \(2000\)](#) conduct economic experiments with local users of ecosystems and find that regulations imposed from outside a community can crowd-out social preferences in favor of greater self-interest. This suggests that external regulations may do more harm than good and may reduce social efficiency to lower levels compared to the case without any outside regulation. For policy it is also of interest to know whether economic incentives and social preferences are substitutes of any kind, in the sense that external incentives crowd-out social preferences, or sort of complements, meaning that specific incentives stimulate the appearance of social preferences ([Bowles and Hwang 2008](#)). In summary, experimental evidence suggests that other-regarding motives may be affected by economic incentives and standard policy may therefore fail, or even be counterproductive when applied to environmental problems.

In Sect. 3 we briefly touched upon three themes related to behavioral economics, namely heterogeneity, evolution and happiness. Heterogeneity and evolution are closely connected as evolutionary thinking involving a framework developed around the notions of diversity, population, selection, inheritance, innovation, coevolution, group selection, path-dependence and lock-in. This relates to an often misunderstood relationship between evolution and progress, where 'what is' is often confused with 'what ought to be'. However, the long-standing debate on evolutionary progress suggests that evolution has some elements of directionality and progress, although it is not identical with continuous progress, among other reasons because selection is a local search process and adaptation is a compromise between different objectives, due to historical constraints that limit evolutionary improvements, and because of the presence of coevolution, which means that the notion of optimization in a fixed setting is lost. [van den Bergh and Kallis \(2009\)](#) consider evolutionary policies at two levels: institutional, i.e. policy change itself, and policy design. Central at the first level is the idea that political and economic environments impose selective pressures on alternative political strategies and that political agents adapt their strategies to this selection environment which is multi-dimensional (media, elections, public opinion, power and lobbying). Historical constraints or path-dependencies are relevant, leading to the notion of "policy paradigm", which reflects the fact that earlier historical events greatly influence and hamper political and institutional developments at a later stage. This view of evolutionary policy is most developed in the literature on innovation policy ([Witt 2003](#)) and, more recently, analysis of transitions to sustainable energy and transport systems ([Safarzyńska and van den Bergh 2010](#)), but may also hold promises for environmental regulation given that behaviors are heterogeneous and

interactive. It even allows for studying types of instruments other than traditional equilibrium analysis based on representative, rational agents. An example is a model by [Nannen and van den Bergh \(2010\)](#) which assumes that the fitness of an economic strategy is determined by the relative welfare of the associated agent compared to its immediate neighbors in a social network. This enables the study of policies affecting relative positions of individuals. Two innovative policies are analyzed, namely “prizes” or rewards, directly altering relative welfare, and “advertisement”, affecting the social network of interactions. The study illustrates the fact that evolutionary analysis enlarges the scope of economic policy analysis. Finally, some of the main policy findings in the happiness literature, notably on status good taxation, have already been mentioned. These not only show that relative positions matter for the environmental impact of human behavior but also for human well-being. They underpin the relevance of environmental policy instruments like information or status taxes ([Brekke and Howarth 2002](#)) that recognize or make use of such behavioral features.

## 5.2 Implications for Climate Policy

The most important current area of environmental policy making is undoubtedly climate policy, covering both the mitigation and reduction of emissions of greenhouse gases and adaptation to climate change. Most current proposals for climate change policy rest on assumptions of rational behavior. Behavioral economics is particularly useful as an alternative basis for climate policy analysis, as it offers distinct views on decision-making under risk and uncertainty and in intertemporal settings. Few studies have so far addressed this issue ([Gowdy 2008](#); [Brekke and Johansson-Stenman 2008](#)). We have summarized evidence here which indicates that climate policy as proposed might not work as efficiently and effectively as intended due to bounded rationality and other-regarding preferences.

The assessment of the psychological dimension of adaptation to climate change has been so far grossly neglected. Clearly, individual decisions about adaptation to climate change are influenced by psychological and cognitive factors, in particular concerning the evaluation of risk probabilities and risk perceptions. It is important to understand the determinants of decisions under uncertainty in order to improve individual risk judgment. The literature suggests that the effects of decision heuristics and cognitive biases on policy success can be profound. There is a fairly large literature on one particular cognitive factor, namely risk perception. Empirical evidence supports biases in risk perception influencing notably insurance and self-protection decisions focusing on natural disasters. For example, [Viscusi and Zeckhauser \(2006\)](#) assess behavioral responses in the realm of risk connected to climate mitigation actions. Some of the behavioral biases or irregularities they observe are “percent thinking bias”, i.e. individuals having problems to perceive percentages correctly, and lack of accessibility of information, both leading to magnified estimates of risk. Similarly, [Kunreuther et al. \(2010\)](#) assess behavioral failures under uncertainty. They argue that individuals use simplified decision rules and fall back onto psychological strategies that depart from economic rationality, e.g. using heuristics such as underweighting the future, myopia in planning, underestimating risk, optimistic bias, and forecasting errors which limit people’s ability to invest in hazard mitigation measures. Such failures to adequately perceive risks and process information may lead to inadequate levels of insurance and in turn to losses from natural disaster which could have been prevented. Inefficiencies that arise from decision making deviating from rationality assumptions in the realm of natural disasters can be ameliorated, among others, by the following policy measures: improving risk communication and implementing risk control mechanisms such as mandatory insurance ([Viscusi 1995](#)); setting prior steps to disasters to ensure efficient behavior of those exposed to the risk, such as regulations

in the form of zoning restrictions (Kunreuther and Pauly 2006); restrict voluntary choices and impose stricter regulations; and guide individuals to make more efficient protective decisions through readjusting insurance contracts and tax incentives (Kunreuther et al. 2010).

An interesting experiment providing information about how to improve risk communication is Wakker et al. (2007) providing experimental data on the effect of statistical information on risk and ambiguity attitudes and on rational insurance decisions. From a policy perspective they recommend that in order to maximize the number of insurances taken, providing particularly individual cost information can increase adoption of insurance products. The first theoretical analysis using behavioral economics of the role of insurance in response to climate change risks is by Botzen and van den Bergh (2009). They take into account alternative theories of individual decision-making under uncertainty, namely Prospect and rank-dependent utility, to investigate whether there is a potential for a private market for natural disasters. This has important implications for climate policy as no insurance against natural hazards such as floods is currently available in the Netherlands, even though insurance might be a useful instrument to promote adaptation to increased flood risk. They test whether individuals are willing to pay for private insurance and estimate risk premiums for flood insurance under different climate change scenarios. This leads to higher WTP values than under expected utility theory assumptions. As a result, a private insurance market for floods in the Netherlands turns out to be feasible. Overall, making more realistic assumptions about individual behavior and decision-making can increase the relevance of insights for policy makers as well as for insurance companies.

Patt and Schröter (2008) examined decisions by farmers and policy makers to implement and adopt measures against the risk of flooding. Using quantitative and qualitative data, they found that farmers exhibit a status quo bias. This means that any adaptation action taken is likely to be avoided because decision and adaptation behavior is influenced by certain heuristics. Also policy makers were found to judge the seriousness and likelihood of climate-related events as greater than farmers living in the affected area. This difference in the risk perception of the two groups can be due to the use of mental shortcuts, as represented by the availability or representativeness heuristics (see also Marx et al. 2007). Grothmann and Patt (2005) include risk perception and perceived adaptive capacity as important cognitive constraints in studying adaptation decisions. For example, they find that individual risk perception of farmers deviates from objectively assessed risk which is in line with probability weighting theory. This means that they underweight large and overweight small probabilities. As a result, individual decision-making subject to such cognitive bias does not lead to optimal adaptation decisions. This in turn means that policies are enforced inadequately and can fall short of their intended goals. One solution suggested is to involve people not only in the process of implementing climate adaptation policies but also in designing them. In other words, a participatory mechanism might contribute to policy success. In addition, a broader model of human decision making by these authors suggests that policy makers remove any cognitive barriers to adaptation, for example, through better risk communication to improve adaptive capacity. The complete list of cognitive factors hampering human rationality (Table 1) and leading to decision biases indicates a large set of factors affecting adaptation decisions and adaptive capacity. More research is needed to assess the magnitude of the various biases in order to design adequate (effective and efficient) policies.

Others have focused on explaining the psychological aspects of mitigation behavior, i.e. a reduction of greenhouse gases. Lange and Treich (2008) present a theoretical framework illustrating some implications for climate policy of in particular ambiguity on individual decisions making. While the majority of studies find that ambiguity reduces mitigation efforts, they show that ambiguity might lead to stricter abatement policies. Ambiguity is relevant to

climate policy as experts disagree in their predictions of future climatic change and potential damage (although the large majority, united in IPCC, agrees about broad strokes of climate change). The authors assume an ambiguity-averse decision maker who deviates from the assumption of expected utility maximization and show that ambiguity aversion can cause decision makers to react to uncertainties regarding future damages by reducing emissions. Other insights come from studies analyzing effective communication of ambiguity, for example, on the basis of IPCC reports on the state of climate science to inform the international policy process. In this context, [Karp \(2005\)](#) recommend to incorporate definitive quantitative evidence if available while [Risbey and Kandlikar \(2007\)](#) suggest reducing linguistic sources of ambiguity. Notice that IPCC is very careful in its use of language related to uncertainty, such as “likely”, “very likely”, “more likely than not”, “likely in some regions”, etc.

Some studies have examined cognitive factors, including knowledge and feelings and their importance for public support concerning the reduction of greenhouse gas emissions. [O’Connor et al. \(2002\)](#) find that individuals who can more accurately identify the causes of climate change and who expect bad consequences from climate change are more likely to undertake voluntary actions and to support stringent government policy. Furthermore, cognitive variables such as knowledge of the causes of climate change better explain mitigation decisions like the purchase of energy-efficient appliances than economic variables do. [Lorenzoni et al. \(2007\)](#) study psychological barriers to behavioural change in the context of adopting alternative energy options. They find that a number of cognitive barriers hinder individual responses to climate change, including habitual use of cars, lack of knowledge, scepticism as a response to uncertainty, distrust in information sources, externalisation of responsibility (blaming others), and pressure of social norms. Similar to what was found for the adaptation literature, these results highlight the necessity for policy to manage and use communication mechanisms more effectively. One suggestion from this study is to better meet the need for basic information in a (more) credible and transparent way. This may include using social marketing techniques to create awareness, acceptance and norms in respect of climate change action among social groups and their networks. More credible communication can also be realized through conveying climate change solutions more personally, that is, by emphasizing and reinforcing the connection between personal action and impact on the climate. Education in schools, books and newspaper can play a major role in facilitating a social change by creating appropriate knowledge and norms. In addition, interventions can be designed to interrupt habitual behaviours and to encourage consideration of green alternatives (e.g., stimulating public transport).

The discussion in Sect. 5.1 about framing and how policy makers, researchers and the public differently frame and interpret climate change problems and how this in turn affects individual mitigation decision is explored by [Yarnal et al. \(2003\)](#). They did a survey where global warming was once framed in terms of the local impacts and once in terms of the national impacts of taking mitigation measures. Respondents’ willingness to support government policies turned out to be significantly different between these two frames, and also the level at which they are willing to take voluntary action differs. Different frames can lead to different responses from individuals. This has implication for the use of local and national scenarios for communicating climate change. In particular, there seems to be an added value of downscaling mitigation scenarios to local measures and strategies. In other words, translating and framing climate change as a local issue can enable the public to work with this problem in a local context. Framing it as a national or global issue, the dominant approach right now, may make it more difficult for individuals to understand why climate change may be relevant for them personally or for their local community or city. Against this background, the campaign Cities for Climate Protection (CCPC) ([Lindseth 2004](#)) which



has taken the local level as the relevant geographical space for climate protection may be an effective approach to organize responses to climate change. Not only spatial but also other frames such as those relating to time dimensions may affect responses to climate change. Time framing means that information about weather and climate (change) can be provided on a daily, weekly or monthly basis. The time factor may be especially relevant for responses by farmers and insurers.

The question how people trade off the cost and benefits of future consumption is of crucial importance to long-run environmental problems like climate change. Environmental conservation is determined by time preferences, i.e. preferences for current versus future states. Behavioral economics suggests hyperbolic discounting, implying that future cost and benefits receive greater weight than under the traditional assumption of exponential discounting. This generally results in a stronger support for stringent, safe climate policy and project choices more in line with long-run sustainability. Hyperbolic discounting in relation to climate change has been discussed by [Arrow et al. \(1996\)](#); [Dasgupta et al. \(1999\)](#); [Howarth \(2003\)](#); [Settle and Shogren \(2004\)](#); [Karp \(2005\)](#), and [Brekke and Johansson-Stenman \(2008\)](#).

Climate protection can be regarded as a large-scale social dilemma, as it involves a global public good (the atmosphere or climate conditions). The study of climate negotiations and voluntary cooperation therefore involve features of public goods as well. However, much of this research excludes other-regarding preferences, including fairness, reciprocity and social approval, and instead assumes self-interested motives only. Especially the interaction of particular risks and social preferences has been neglected. A rare experimental study of this interaction is [Hill and Buss \(2010\)](#). They find that positional and status concerns can reverse the well documented certainty effect. In other words, concerns for relative positions can lead to increased risk taking. This insight highlights the relevance of the connection between social preferences and preferences for risk where social comparison may stimulate risky behavior. Other experimental research has found that agents in climate negotiations hold social preferences. [Dannenberg et al. \(2007\)](#) used data from interviews with policy makers to find that they have a strong equity preference in climate negotiations, which can explain cooperative behavior observed in international climate negotiations. [Lange and Vogt \(2003\)](#), in a game theoretical approach, argue that fairness orientations, i.e. preferences for equity, can serve as an explanation for countries signing environmental agreements. The strength of social preferences can be important for the design of incentives and institutional institutions for negotiations (see, [Fehr and Falk 2002](#) analyzing principle-agent relationships). For instance, the desire to reciprocate or gain social approval through voluntary actions in the context of climate negotiations should be recognized and perhaps stimulated. [Alpizar et al. \(2009\)](#) using a framed field experiment study the effect of risk and ambiguity on farmers' willingness to cooperate when adapting to climate change. It was found that in particular communication improved coordination under ambiguous conditions and lead to reduced adaptation costs.

In addition, material incentives, social rewards and punishment might be an option for increasing cooperative behavior. Indeed, price based instruments such as emission trading may not work effectively when other than price factors influence market behavior. Experiments discussed in Sect. 2.2 show that cooperation can be established if a punishment opportunity, such as an incentive in form of social disapproval, exists. Besides material punishment, social disapproval can lead to more cooperative outcomes compared to situations with incentives that are due to formal regulatory policy. Thus, in order to improve the effectiveness of a bargaining system [Brekke and Johansson-Stenman \(2008\)](#) suggest introducing an institutional structure involving punishment and sanctioning mechanisms to leverage reciprocity norms and cooperation. This will benefit the equity outcomes of negotiations and improve the effectiveness of a bargaining system.

The existence of other-regarding preferences is not only relevant to climate agreement negotiations but also in the context of individual emission reduction through more stringent climate policy in areas like transport, energy and consumption. The reason is that other-regarding preferences, like social norms, intrinsic motivation, and altruism, can lead to voluntary environmentally responsible behavior (see also Sect. 5.2). [Rauscher \(2006\)](#) presents a theoretical model analyzing the effect of imposing an emission tax on voluntary cooperative behavior. He finds that behavior motivated by social motives and intrinsic motivation may be undermined by the implementation of a standard policy instrument originally designed to affect self-interested individuals. This is in line with the wider literature on regulatory policy crowding-out intrinsic motivations. Clearly, the introduction of a regulatory tax may, overall, reduce voluntary abatement efforts and, in the worst case, even lead to an increase in emissions.

Two examples of non-pecuniary incentives having a significant impact on behavior and climate protection relate to status and social norms. Recent experimental research shows that potential gains from social reputation act as a strong incentive for investing in climate protection measures. It is found that individual investments in climate protection are highest if subjects are aware that their investment decision is made public, hence giving room to social reputation effects ([Milinski et al. 2006](#)). In the context of climate policy, effective public disclosure mechanisms can take the form of publicizing GHG emissions and people's energy usage or placing stickers on environmentally pollutive cars ([Rand and Nowak 2009](#)). An empirical example comes from the City of Austin, which during a period of drought decided to publicize information about the highest water use by private homes. This form of public disclosure substantially decreased water consumption ([McKinley 2008](#)).

Reputation effects can also be important for the purchase of green products. [Griskevicius et al. \(2010\)](#) argue that buying a green product may enable an individual to signal pro-social behavior to others. Activating status or self-image concerns might therefore lead people to engage in "conspicuous conservation". This hypothesis was examined in an experimental study that analyzed the influence of status on the choice of non-green and green products. In view of this, green products might be advertised in a way that links them to status attributes. For instance, the visibility of status-enhancing acts can be promoted by using badges, signs or tags so that individuals can display their pro-social acts. An experimental study by [Alpizar et al. \(2005\)](#) estimated the degree of positionality for a range of goods finding that even insurances are prone to relative concerns and positional effects. For climate adaptation this could mean that marketing of insurances through activating status might be an effective strategy to increase adoption of insurances and self-protection.

Another powerful driver of human action is social norms and social pressure. Research in social psychology by [Cialdini \(2003, 2007\)](#) suggest that communication employing social-norm based appeals to elicit pro-environmental behavior can sometimes be superior to traditional mechanisms such as price changes, probably within limits. Their argument is that social influence aimed at complying with social norms leads to two distinct benefits: maintenance of social relationships and of a favourable self-image. Behavior by others can be a strong personal motivation to spur compliance with environmental responsible behaviour. Therefore, social cognitive factors deserve greater attention in environmental policy design. For example, [Ayres et al. \(2009\)](#) illustrate that peer pressure can be successfully used to promote energy conservation. Using field experiments they show that if individual behavior is compared with conservation practices of neighbours, people can be persuaded to reduce emissions and energy consumption. It is found that those who are provided with information about the energy conservation of their neighbours are more likely to conserve energy themselves. They



suggest that mechanisms like peer comparison and feedback, benchmarking, and ranking can contribute to stimulating socially desirable behavior.

Nannen and van den Bergh (2010) is a rare study which combines behavioral economics (bounded rationality and relative welfare) and evolutionary or population interactions between individuals in order to study climate policies affecting the choice between investment in fossil fuel and renewable energy technologies. As discussed in the previous section, this model employs two new types of instruments, namely “prizes” and “advertisement”, which are compared in performance with traditional environmental externality taxes. The new instruments have the advantage that they stimulate the spread of information and network formation in a world characterized by imperfect information and bounded rationality. Similarly, Schwarz and Ernst (2009) combine empirical data with agent-based modeling in studying the diffusion of water-saving innovations in Germany. Besides recommending strong regulations for the adoption of such innovations, they suggest that information campaigns using different types of public information channels can support the diffusion of such sustainable innovations. Hence, communication strategies influencing social networks may be a complementary policy strategy to diffuse innovations.

Policy lessons from the happiness literature suggest that, as a result of an income threshold above which happiness is at best weakly correlated with income (Easterlin 1974), stringent climate change policies in developed countries might not have the intended strong, negative effects on individual well-being as predicted by standard economics (Sekulova and van den Bergh 2010). This threshold effect is due to basic needs being satisfied, the presence of relative welfare effects, and people’s tendency to adapt to changing circumstances. The latter would mean that individuals are capable of adapting to new circumstances and after a brief transition period will approximate or restore their original well-being level (Cohen and Vandenbergh 2008). However, this will not occur with regard to all changes. Especially extreme climate change may affect feelings of security and basic needs of people, notably in developing countries, which is likely to negatively affect well-being. All in all, happiness research seems to suggest a more stringent, precautionary climate policy than traditional economics informed by classical cost-benefit analysis (van den Bergh 2010).

Based on the results and arguments in this section, we suggest to adapt and complement regulatory climate policy in three ways: (1) ameliorate decision biases or errors relating to decisions under uncertainty, risk and ambiguity, common to the context of climate change, through corrective policy; (2) develop non-pecuniary strategies to trigger social preferences and include social context aspects in communication strategies to encourage pro-environmental behavior; (3) be aware of geographical and temporal framing effects in designing policies and communicating information.

## 6 Conclusions

Standard economic theory assumes that individuals are fully rational and act in a self-interested manner. This has provided a very clear perspective on what efficient and effective environmental policy entails. Evidence from psychology and economics has enhanced our understanding of how people behave and make certain decisions. It turns out that observed behavior, notably in experiments, deviates from rational behavior or at least challenges its strong assumptions. In response, behavioral economics has developed alternative explanations for, and theories of, economic behavior. In particular, bounded rationality and other-regarding preferences are psychological regularities which alter the design of effective and efficient policy. This research stresses the relevance of behavioral anomalies and social

motivations affecting individual decision-making in a wide range of environmental contexts ranging from energy decisions by households to negotiations for an international climate agreement. By assuming a more realistic picture of individual behavior, behavioral economics makes it possible to draw robust environmental policy conclusions under conditions of bounded rationality and other-regarding preferences.

Boundedly rational agents are unable to make optimal decisions, which has implications for many aspects of environmental policy design. This covers a wide variety of issues, such as the effectiveness and efficiency of environmental regulation including the use of economic (market-based) instruments, the consistency of sovereignty of preferences and paternalistic policy with long-run sustainability, specific policy framing to improve policy success, and recognizing adaptation (in well-being terms) to changed circumstances like higher energy prices. An important finding of behavioral environmental policy analysis is that policy should go beyond price-based regulation or market-based instruments; that is, it should not place its trust only in price signals—without denying that the latter are an essential part of many good, effective policies. From an environmental welfare perspective, more competition in retail markets might not be enough to encourage a behavioral change towards a sustainable transition, such as the large-scale application of green alternatives (e.g., renewable energy technologies) but rather requires additional policies. For example, presenting green alternatives as the default option for consumers, lowering information costs (deliberation, information, marketing campaigns, and education) and increasing taxation on status and habitual goods with high environmental impacts can have a positive effect on sustainable consumption behavior. This holds true for environmental policies seeking to stimulate behavioral change in everyday, habitual activities with environmental significance. For example, using higher fuel prices in an attempt to change transport behavior might not be enough to break bad habits or even to establish and create pro-environmental habits. The formation of good habits may be encouraged by monetary incentives, but, if intrinsic motivations are strong, such incentives can be counterproductive. Even though some policies of this kind may be seen as inconsistent with respecting consumer sovereignty, they seem legitimate if consumer preferences are inconsistent with long-run sustainability. Indeed, in other areas like public health (smoking, sexual behavior, driving behavior), consumer preferences are not taken for granted as public policies are aimed precisely at changing them.

The review suggests that not all economic decisions can be reduced to self-interested consumer choice. Economic psychology supports the existence of social norms contributing to voluntary environmental behavior, i.e. consumers' pro-environmental behavior being founded in altruistic preferences, moral motivation, social duty orientations and other social preferences. Empirical evidence indicates that consumers are sufficiently altruistic (pure or impure altruism), care about the expectations of others (status and conformity) and hold general concerns about their social responsibility. Policy strategies can include the stimulation of social preferences, for example, to foster voluntary environmental action and agreements. Effective policies to address these situations include social rewards and punishment mechanism, such as the activation of citizen duty through social punishment (social stigma), and information channels including the media, marketing campaigns and education, through which social norms can be mediated and linked to a variety of environmental externality problems. This may have implications for equity preferences and international environmental agreements. In particular, social punishment and reward mechanisms put in place can improve the effectiveness of international climate policy negotiations.

As the purchase of "green goods" is strongly connected to self-identity concerns, meaning that commodities may serve to communicate or reinforce one's self-image to others, the revelation of identity and information about the behavior or expectations of others

(conformity) may have some impact on “green consumer behavior”. The mechanism behind these norms is not fully understood and there is more to learn concerning the formation and stability of voluntary environmental preferences based on social norms in order to inform environmental policy.

Next, an important finding of norms and rules in social dilemma situations is that externally imposed, formal regulation can reduce or completely destroy informative, voluntary and often evolved cooperative behavior, notably in common-pool resource situations. Such regulatory policies may then perform poorly or even become counterproductive. The reason is that such policies do not take into account social interactions that influence an agent’s behavior. Indeed, much can be gained by activating social motives like fairness, reciprocity or moral duty in support of cooperation. Policy can be linked to stimulation or activation of norms through trust, communication, social interaction and contribute to the formation of preferences supporting cooperation. For instance, the stimulation of reciprocal behavior can increase donations to public goods. Linking policy to a variety of social, non-selfish and other-regarding preferences can “crowd-in” and stabilize rather than “crowd-out” voluntary environmental behavior. Other policy strategies involving social interactions between individuals include more intense self-regulation (informal rules) due to reciprocity and repeated interactions and the support of participatory mechanism in the design of adaptation strategies to climate change. Not only the presence of these sentiments but also the incongruence of social preferences with existing institutional structures like property rights needs to receive attention in policy design. This also serves as an explanation for the existence of many environmental conflicts around the world, whereas traditional economic theory suggests that Coasean solutions in the negotiation between polluter and victim would be more common.

A final conclusion is that behavioral theories have important implications for climate policy. Decisions relevant to climate change are made under conditions of uncertainty where cognitive and psychological constraints influence individual risk judgments about the probability of outcomes and extreme events. Incorporating more realistic assumptions based on evidence that individual decisions on particularly adaptation measures rely on heuristics can improve the design of incentives and institutions, such as those promoting natural hazard insurance. Other policy recommendations are the implementation of effective risk communication practices and participatory mechanisms in order to improve the decision-making capacity of individuals and organizations regarding appropriate adaptation measures. Like cognitive issues, other-regarding preferences and social norms affecting environmental decision-making have been sporadically addressed in the analysis of climate policy. Only a few studies have considered these issues in the context of climate negotiations. Institutional arrangements accounting for behavioral and social features of individuals are necessary to overcome large scale collective action problems such as climate change. Our proposal is that regulatory climate policy includes corrections to ameliorate decision biases relating to decisions under uncertainty, is extended with non-pecuniary strategies to encourage pro-environmental behavior and accounts for geographical and temporal framing effects in communicating information about policies.

## 7 Potential Research Avenues

The recent import of insights from behavioral economics into environmental economics means that there are still many unresolved issues. We therefore end this paper by listing some suggestions for further research.

Research on sustainable consumption and pro-environmental behavior needs to address the question which combination of pecuniary and non-pecuniary instruments works most effectively in terms of reducing environmental impact of household and individual behavior. In designing and evaluating the effectiveness of non-pecuniary policy strategies aimed at communicating the individual and social benefits of pro-environmental behavior, it may be useful to examine what can be learned from social marketing approaches which can stimulate reputation effects in social networks to create responsible environmental behavior. In addition, experiments with an explicit environmental setting can be aimed at examining the impact and effectiveness of a variety of incentives—working through reputation, approval and fear—on people's willingness to behave pro-environmentally, choose green products or invest in adaptation to climate change. The assessment of policy effectiveness should further take into account potential (energy or environmental) rebound effects, which possibly may arise when attention in policy shifts from regulation to information provision and moral suasion. The outcome of such considerations may improve our insight on the right balance between the various instruments.

Efficiency has been the dominant criterion for evaluation and comparison of policy instruments in environmental economics. Since social efficiency (or more limitedly, cost-effectiveness) depends on individual efficiency, which is lower in the case of bounded rationality, the efficiency evaluation of policy needs possibly to be adapted or at least done with more care for cases where bounded rationality matters. Taking a broader perspective, Table 3 provided a qualitative assessment of the consequences of the various classes of behavioral features identified in Sect. 2 on core policy criteria, including also equity. Further research is needed to arrive at a more definite judgment on this.

Another potential research avenue is the role of status-seeking behavior in the consumption of goods and services with a relatively high contribution to environmental pressure. Somewhat related is the role of (social) marketing in stimulating such consumption, and how potentially misleading information can be controlled or countered with beneficial impacts in terms of both reducing environmental pressure and improving individual well-being. This is the negative side of status-seeking. On the other hand, status feelings might be employed to stimulate the adoption of cleaner products and services, such as hybrid cars. Research on this is lacking.

Regarding the link between monetary valuation and policy, it is relevant to understand what bounded rationality means for biases in valuation of environmental externalities, and in turn for the formulation of externality regulation through (optimal) charges or levies, as well as for the formulation of monitoring-and-control through the setting of fine levels. At least we should try to get a general idea about whether biases are upward or downward under certain conditions or for specific types of environmental problems.

Many of the general policy insights can be immediately transferred to climate change, while the latter also provides specific problems and instances of behavioral issues and in turn specific problems for the design of climate policy. The impact of ambiguity of climate change and its consequences evidently needs more research and some of it is already underway. The role of bounded rationality in the formation of international climate agreements might receive more attention, to arrive at realistic views on the limits and opportunities for agreement-making. Another relevant topic is the impact of social context and information about low-probability/high-impact scenarios on adaptation decisions, such as the purchase of insurances, which has received only sporadic attention so far.

## References

- Abrahamse W, Steg L, Vlek C, Rothengatter T (2005) A review of intervention studies aimed at household energy conservation. *J Environ Psychol* 25:273–291
- Ackerman F (1997) Why do we recycle? Markets, values, and public policy. Island Press, Washington DC
- Alchian A (1950) Uncertainty, evolution and economic theory. *J Polit Econ* 58:211–222
- Alpizar F, Carlsson F, Johansson-Stenman O (2008) Anonymity, reciprocity, and conformity: evidence from voluntary contributions to a national park in Costa Rica. *J Public Econ* 92:1047–1060
- Alpizar F, Carlsson F, Johansson-Stenman O (2005) How much do we care about absolute versus relative income and consumption? *J Econ Behav Organ* 56(3):405–421
- Alpizar F, Carlsson F, Naranjo M (2009) The effect of risk, ambiguity and coordination on farmers' adaptation to climate change: a framed field experiment. RFF Discussion Paper EfD DP 09-18
- Andreoni J (1989) Giving with impure altruism: applications to charity and ricardian equivalence. *J Polit Econ* 97(6):1447–1458
- Andreoni J (1990) Impure altruism and donations to public goods: a theory of warm-glow giving. *Econ J* 100:464–477
- Andreoni J, Miller J (2002) Giving according to GARP: an experimental test of the consistency of preferences for altruism. *Econometrica* 70:737–753
- Ashraf N, Karlan D, Yin W (2006) Tying odysseus to the mast: evidence from a commitment savings product in the Philippines. *Q J Econ* 121(2):673–697
- Arrow KW, Cline KG, Maler M, Munasinghe M, Squitieri R, Stiglitz J (1996) Intertemporal equity, discounting, and economic efficiency. In: Bruce HLJP, Haites E (eds) *Climate change 1995: economic and social dimensions of climate change*. Cambridge University Press, Cambridge, pp 128–144
- Ayres I, Raseman S, Shih A (2009) Evidence from two large field experiments that peer comparison feedback can reduce residential energy usage. NBER Working Paper No. 15386
- Barr S, Gilg AW, Ford N (2005) The household energy gap: examining the divide between habitual—and purchase-related conservation behaviours. *Energy Policy* 33:1425–1444
- Baumol WJ, Oates WE (1975) *The theory of environmental policy*. Prentice-Hall, Englewood-Cliffs
- Becker GS, Murphy KM (1988) A theory of rational addiction. *J Polit Econ* 96:675–700
- Bénabou R, Tirole J (2003) Intrinsic and extrinsic motivation. *Rev Econ Stud* 70(3):489–520
- Bénabou R, Tirole J (2006) Incentives and prosocial behaviour. *Am Econ Rev* 96(5):1652–1678
- Berglund C (2006) The assessment of households' recycling costs: the role of personal motives. *Ecol Econ* 56:560–569
- Biel A, Thøgersen J (2007) Activation of social norms in social dilemmas: a review of the evidence and rejection on the implications for environmental behaviour. *J Econ Psychol* 28:93–112
- Bohm P (1972) Estimating demand for public goods: an experiment. *Eur Econ Rev* 3:111–130
- Botzen W, van den Bergh J (2009) Bounded rationality, climate risks, and insurance: is there a market for natural disasters. *Land Econ* 85(2):265–278
- Bowles S, Hwang SH (2008) Mechanism design when preferences depend on incentives. *J Public Econ* 92:1811–1820
- Bowles S (2008) Policies designed for self-interested citizens may undermine “The Moral Sentiments”: evidence from economic experiments. *Science* 320:1605–1609
- Boyd R, Richerson PJ (1993) Rationality, imitation, and tradition. In: Day RH, Chen P (eds) *Nonlinear dynamics and evolutionary economics*. Oxford University Press, New York, pp 131–149
- Braga J, Starmer C (2005) Preference anomalies, preference elicitation and the discovered preference hypothesis. *Environ Resour Econ* 32(1):55–89
- Brekke KA, Howarth RB (2000) The social contingency of wants. *Land Econ* 76:493–503
- Brekke KA, Howarth R (2002) Status, growth, and the environment: goods as symbols in applied welfare economics. Edward Elgar, Cheltenham
- Brekke KA, Howarth RB, Nyborg K (2002) Status-seeking and material affluence: evaluating the Hirsch hypothesis. *Ecol Econ* 45:29–39
- Brekke KA, Kverndokk S, Nyborg K (2003) An economic model of moral motivation. *J Public Econ* 87:1967–1983
- Brekke KA, Kipperberg G, Nyborg K (2007) Reluctant recyclers: social interaction in responsibility ascription. Memorandum 16/2007, Oslo University, Department of Economics
- Brekke KA, Johansson-Stenman O (2008) The behavioural economics of climate change. *Oxford Rev Econ Policy* 24(2):280–297

- Brookshire D, Coursey D, Schulze W (1990) Experiments in the solicitation of private and public values: an overview. In: Green L, Kagel J (eds) *Advances in behavioral economics II*. Ablex Publishing Corporation, New York
- Brown PM, Stewart S (1998) Avoiding severe environmental consequences: evidence on the role of loss avoidance and risk attitudes. *J Econ Behav Organ* 38:179–198
- Caballero MC (2004) Academic turns city into a social experiment. *Harvard University Gazette*, Cambridge
- Camerer C (1995) Individual decision making. In: Roth A, Kagel J (eds) *Handbook of experimental economics*. Princeton University Press, Princeton
- Camerer C (1999) Behavioral economics: reunifying psychology and economics. *Proc Natl Acad Sci* 96:10575–10577
- Camerer C (2004) Prospect theory in the wild: evidence from the field. In: Camerer C, Loewenstein G, Rabin M (eds) *Advances in behavioral economics*. Princeton University Press, Princeton
- Camerer C, Weber M (1992) Recent developments in modelling preferences: uncertainty and ambiguity. *J Risk Uncertain* 5:325–370
- Camerer C, Issacharoff S, Loewenstein G, O'Donoghue T, Rabin M (2003) Regulation for conservatives: behavioral economics and the case for “Asymmetric Paternalism”. *Univ PA Law Rev* 151(3): 1211–1254
- Camerer CF, Loewenstein G, Rabin M (eds) (2004) *Advances in behavioral economics*. Princeton University Press, Princeton
- Camerer C, Fehr E (2006) When does ‘economic man’ dominate social behavior? *Science* 311:47–52
- Cardenas JC, Stranlund J, Willis C (2000) Local environmental control and institutional crowding-out. *World Dev* 28(10):1719–1733
- Cardenas JC, Ostrom E (2004) What do people bring into the game? Experiments in the field about cooperation in the commons. *Agric Syst* 82/3:307–326
- Carpenter J, Myers C (2007) Why volunteer? Evidence on the role of altruism, reputation, and incentives, Middlebury College Working Paper Series 0712, Middlebury College, Department of Economics
- Cardenas JC, Carpenter J (2008) Behavioural development economics: lessons from field labs in the developing world. *J Dev Stud* 44(3):311–338
- Carrus G, Passafaro P, Bonnes M (2008) Emotions, habits and rational choices in ecological behaviours: the case of recycling and use of public transportation. *J Environ Psychol* 28:51–62
- Charness G, Gneezy U (2008) Incentives to exercise. *Econometrica* 77(3):909–931
- Cheema A, Soman D (2006) Malleable mental accounting: the effect of flexibility on the justification of attractive spending and consumption decisions. *J Consum Psychol* 16(1):33–44
- Cherry T, Crocker T, Shogren J (2003) Rationality spillovers. *J Environ Econ Manage* 45:63–84
- Cialdini R (2003) Crafting normative messages to protect the environment. *Curr Dir Psychol Sci* 12(4): 105–109
- Cialdini R (2007) Descriptive social norms as underappreciated sources of social control. *Psychometrika* 72(2):263–268
- Clark CF, Kotchen MJ, Moore MR (2003) Internal and external influences on pro-environmental behavior: participation in a green electricity program. *J Environ Psychol* 23:237–246
- Cohen MA, Vandenbergh MP (2008) Consumption, happiness, and climate change. RFF Discussion Paper No. 08-39, Washington
- Conlisk J (1996) Why bounded rationality?. *J Econ Lit* 34(2):669–700
- Dannenberg A, Sturm B, Vogt C (2007) Do equity preferences matter in climate negotiations? An experimental investigation. ZEW Discussion Paper No. 07-063, Mannheim
- Dasgupta P, Maler KG, Barrett S (1999) Intergenerational equity, social discount rates, and global warming. In: Portney PR, Weyant JP (eds) *Discounting and intergenerational equity*. Resources for the Future, Washington, DC
- Deci EL (1972) Intrinsic motivation, extrinsic reinforcement and inequity. *J Pers Soc Psychol* 22:113–120
- Defeuilley C (2009) Retail competition in electricity markets. *Energy Policy* 37:377–386
- Duesenberry JS (1949) *Income, saving, and the theory of consumer behaviour*. Harvard University Press, Cambridge
- Easterlin RA (1974) Does economic growth improve the human lot? In: David PA, Readers MW (eds) *Nations and households in economic growth: essays in honour of Moses Abramovitz*. Academic Press Inc, New York
- Easterlin RA (2001) Income and happiness: towards a unified theory. *Econ J* 111(473):465–484
- Ehmke M, Shogren JF (2008) Experimental methods for environment and development economics. *Environ Dev Econ* 1:1–38
- Ek K, Söderholm P (2008a) Household's switching behavior between electricity suppliers in Sweden. *Utilities Policy* 16:254–261



- Ek K, Söderholm P (2008b) Norms and economic motivation in the Swedish green electricity market. *Ecol Econ* 68:169–182
- Ellingsen T, Johannesson M (2008) Anticipated verbal feedback induces altruistic behaviour. *Evol Hum Behav* 29(2):100–105
- Ellsberg D (1961) Risk, ambiguity, and the savage axioms. *Q J Econ* 75:643–669
- Eriksson L, Garvill J, Nordlund AM (2008) Interrupting habitual car use: the importance of car habit strength and moral motivation for personal car use reduction. *Transp Res F* 11(1):10–23
- Faiers A, Cook M, Neame C (2007) Towards a contemporary approach for understanding consumer behaviour in the context of domestic energy use. *Energy Policy* 35:4381–4390
- Falk A (2004) Charitable giving as a gift exchange evidence from a field experiment. IZA Discussion Paper No. 1148; ISSN Working Paper No. 168
- Falk A, Fischbacher U (2006) A theory of reciprocity. *Games Econ Behav* 54(2):293–315
- Fehr E, Schmidt KM (1999) A theory of fairness, competition and cooperation. *Q J Econ* 817(865):817–865
- Fehr E, Gächter S (2000) Fairness and retaliation: the economics of reciprocity. *J Econ Perspect* 14:159–181
- Fehr E, Falk A (2002) Psychological foundations of incentives. *Eur Econ Rev* 46(4–5):687–724
- Fehr E, Gächter S (2004) Fairness and retaliation: the economics of reciprocity. *J Econ Perspect* 14(3):159–181
- Fischbacher U, Gächter S (2006) Heterogeneous social preferences and the dynamics of free riding in public goods. CeDex Discussion Paper No. 2006–01, University of Nottingham
- Fleishman JA (1988) The effects of decision framing on other's behavior on cooperation in a social dilemma. *J Conflict Resolut* 32:162–180
- Frank R (2005a) Does absolute income matter? In: Porta PL, Bruni L (eds) *Economics and happiness*. Oxford University Press, Oxford
- Frank R (2005b) Positional externalities cause large and preventable welfare losses. *Am Econ Rev* 45:137–141
- Frederick S, Loewenstein G, O'Donoghue T (2002) Time discounting and time preference: a critical review. *J Econ Lit* 40(2):351–401
- Frey B (1997) Not just for the money. An economic theory of personal motivation. Edward Elgar Publishing, Cheltenham
- Frey B, Jegen R (2001) Motivation crowding theory: a survey of empirical evidence. *J Econ Surv* 15(5):589–661
- Frey B, Stutzer A (2002) *Happiness and economics: how the economy and institutions affect human well-being*. Princeton University Press, Princeton
- Frey B, Meier S (2004) Pro-social behavior in a natural setting. *J Econ Behav Organ* 54:65–88
- Frey B, Stutzer A (2006) Mispredicting utility and the political process. In: McCaffery EJ, Slemrod J (eds) *Behavioral public Finance*. Russell Sage Foundation, New York, pp 113–140
- Frey BS, Neckermann S (2008) Awards: a view from psychological economics. *J Psycho* 216:198–208
- Friedman M (1953) *Essays in positive economics*. University of Chicago Press, Chicago
- Gächter S (2006) Conditional cooperation: behavioral regularities from the lab and the field and their policy implications. Discussion Papers 2006-03, The Centre for Decision Research and Experimental Economics, School of Economics, University of Nottingham
- Gärling T, Axhausen KW (2003) Introduction: habitual travel choice. *Transportation* 30:1–11
- Gneezy U, Rustichini A (2000) Pay enough or don't pay at all. *Q J Econ* 791(810):791–810
- Gneezy U, List JA (2006) Putting behavioral economics to work: Testing for gift exchange in labor markets using field experiments. *Econometrica* 74:1365–1384
- Gowdy JM (2008) Behavioral economics and climate change policy. *J Econ Behav Organ* 68(3–4):632–644
- Griskevicius V, Tybur JM, Van den Bergh B (2010) Going green to be seen: status, reputation, and conspicuous conservation. *J Pers and Soc Psychol* 98:392–404
- Grothmann T, Patt A (2005) Adaptive capacity and human cognition: the process of individual adaptation to climate change. *Glob Environ Change* 15:199–213
- Gunnarsson S, Shogren J, Cherry T (2003) Are preferences for skewness fixed or fungible. *Econ Lett* 80:1
- Hahn RW (1989) Economic prescription for environmental problems: how the patient followed the doctor's orders. *J Econ Perspect* 3(2):95–114
- Halvorsen B (2008) Effects of norms and opportunity cost of time on household recycling. *Land Econ* 84(3):501–516
- Hammar H, Carlsson F (2001) Smokers' decisions to quit smoking. Working Papers in Economics 59, Göteborg University, Department of Economics
- Hanley N, Shogren J (2005) Is cost-benefit analysis anomaly-proof? *Environ Resour Econ* 32:13–34
- Heinrich J, Boyd R (1998) The evolution of conformist transmission and the emergence of between-group differences. *Evol Hum Behav* 19:215–241

- Heinrich J, Boyd R, Bowles S, Camerer C, Fehr E, Gintis H, McElreath R (2001) In search of homo economicus: behavioral experiments in 15 small-scale societies. *Am Econ Rev* 91:73–78
- Hill SE, Buss DM (2010) Risk and relative social rank: positional concerns and risky shifts in probabilistic decision-making. *Evol Hum Behav* 31:219–226
- Hirsch F (1976) *The social limits to growth*. Harvard University Press, Cambridge
- Hodgson G (1988) *Economics and institutions*. Polity Press, Cambridge
- Hodgson G (2004) Evolutionary economics and habits. In: *The international encyclopaedia of economic sociology*. Routledge, London and New York
- Hoffman E, Spitzer ML (1982) The Coase theorem: some experimental tests. *J Law Econ XXV*:73–98
- Howarth RB (1996) Status effects and environmental externalities. *Ecol Econ* 16:25–34
- Howarth RB (2003) Discounting and uncertainty in climate change policy analysis. *Land Econ* 79:369–381
- Jackson T (2000) Why is ecological economics not an evolutionary science? 3rd Biennial Conference of the European Society of Ecological Economics (ESEE), Vienna University of Economics and Business Administration
- Jackson T (2005) Motivating sustainable consumption: a review of evidence on consumer behaviour and behavioural change. Report Sustainable Development Research Network, Surrey
- Jaffe A, Stavins R (1994) The energy paradox and the diffusion of conservation technology. *Resour Energy Econ* 16(2):91–122
- Janssen M, Jager W (2002) Stimulating diffusion of green products, co-evolution between firms and consumers. *J Evol Econ* 12(3):283–306
- Johansson O (1997) Optimal Pigovian taxes under altruism. *Land Econ* 73:297–308
- Johansson-Stenman O (2002) Environmental policy when people's preferences are inconsistent, non-welfaristic, or simply not developed. In: Bromely D, Paavola J (eds) *Economics, ethics and environmental policy: contested choice*. Blackwell, London, pp 103–119
- Johansson-Stenman O, Martinsson P (2006) Honestly, why are you driving a BMW?. *J Econ Behav Organ* 60:129–146
- Juliosson EA, Gamble A, Gärling T (2007) Loss aversion and price volatility as determinants of attitude towards variable price agreements in the Swedish electricity market. *Energy Policy* 35(11):5953–5957
- Kahan D (2005) The logic of reciprocity: trust, collective action and law. In: Gintis H, Bowles S, Boyds R, Fehr E (eds) *Moral sentiments and material interests: the foundation of cooperation in economic life*. The MIT Press, Cambridge, pp 339–378
- Kahneman D, Tversky A (1974) Judgment under uncertainty: heuristics and biases. *Science* 185(4157):1124–1131
- Kahneman D, Tversky A (1979) Prospect theory: an analysis of decision under risk. *Econometrica XLVII*:263–291
- Kahneman D, Knetsch J, Thaler R (1986) Fairness and the assumptions of economics. *J Bus* 59(4):285–300
- Kahneman D, Knetsch J, Thaler R (1990) Experimental tests of the endowment effect and the Coase theorem. *J Polit Econ* 98:1325–1348
- Kahneman D, Knetsch J, Thaler R (1991) The endowment effect, loss aversion, and status quo bias. *J Econ Perspect* 5(1):193–206
- Kahneman D, Knetsch JL (1992) Valuing public goods: the purchase of moral satisfaction. *J Environ Econ Manage* 22:55–70
- Kahneman D, Tversky A (1992) Advances in prospect theory: cumulative representation of uncertainty. *J Risk Uncertain* 5:297–323
- Kandlikar M, Risbey J, Dessai S (2005) Representing and communicating deep uncertainty in climate change assessments. *Geosciences* 337(4):443–445
- Karp L (2005) Global warming and hyperbolic discounting. *J Public Econ* 89:261–282
- Knight F (1921) *Risk, uncertainty, and profit*. Houghton Mifflin, Boston
- Kotchen MJ, Moore MR (2007) Private provision of environmental public goods: household participation in green-electricity programs. *J Environ Econ Manage* 53:1–16
- Kunreuther H, Ginsberg R, Miller L, Sagi P, Slovic P, Borkan B, Katz N (1978) *Disaster insurance protection: public policy lessons*. Wiley Press, New York
- Kunreuther H, Pauly M (2006) Rules rather than discretion: lessons from Hurricane Katrina. *J Risk Uncertain* 33:101–116
- Kunreuther H, Meyer R, Michel-Kerjan E (2010) Overcoming decision biases to reduce losses from natural catastrophe. In: Shafir E (ed) *Behavioral foundations of policy*. Princeton University Press (forthcoming)
- Laibson D (1997) Golden eggs and hyperbolic discounting. *Q J Econ* 112(2):443–477
- Lange A, Treich N (2008) Uncertainty, learning and ambiguity in climate policy: classical results and new directions. *Clim Change* 89:7–21



- Lange A, Vogt C (2003) Cooperation in international environmental negotiations due to a preference for equity. *J Public Econ* 87(9–10):2049–2067
- Levine MD, Koomey JG, McMahon JE, Sanstad A, Hirst E (1995) Energy efficiency policy and market failures. *Annu Rev Energy Environ* 20:535–555
- Levy H, Levy M, Solomon S (2000) Microscopic simulation of financial markets: from investor behavior to phenomena. Academic Press, New York
- Lichtenstein S, Slovic P (1971) Reversals of preference between bids and choices in gambling decisions. *J Exp Psychol* 89:46–55
- Lindbeck A (1997) Incentives and social norms in household behaviour. *Am Econ Rev* 87(2):370–377
- Lindseth G (2004) The Cities for Climate Protection Campaign (CCP) and the framing of local climate policy. *Local Environ* 9(4):325–336
- List JA (2005) Scientific numerology, preference anomalies, and environmental policymaking. *Environ Resour Econ* 32(1):35–53
- List JA (2006) Using experimental methods in environmental and resource economics. Elgar, Northampton
- Loewenstein G (2007) Behavioral economics. In: Woods J (ed) *Handbook of the philosophy of science*. Elsevier, Amsterdam
- Loewenstein G, Prelec D (1992) Anomalies in intertemporal choice: evidence and an interpretation. *Q J Econ* 107:573–597
- Loewenstein G, Lerner J (2003) The role of affect in decision making. In: Dawson RJ, Scherer KR, Hill Goldsmith H (eds) *Handbook of affective science*. Oxford University Press, Oxford, pp 619–642
- Lorenzoni I, Nicholson-Cole S, Whitmarsh L (2007) Barriers perceived to engaging with climate, change among the UK public and their policy implications. *Glob Environ Change* 17:445–459
- Löfgren A, Nordblom K (2006) The importance of habit formation for environmental taxation. Working papers in economics no. 204. Department of Economics, Göteborg University
- Marx S, Weber E, Orlove B, Leiserowitz A, Krantz D, Roncoli C, Phillips J (2007) Communication and mental processes: experiential and analytic processing of uncertain climate information. *Glob Environ Change* 17(1):47–58
- Marechal K (2009) An evolutionary perspective on the economics of energy consumption: the crucial role of habits. *J Econ Issues* (forthcoming)
- McCaffery EJ, Baron J (2006) Thinking about tax. *Psychol Public Policy Law* 12:106–135
- McKinley JC (2008) Champion cyclist and now champion guzzler of Austin water. *The New York Times*. Retrieved from <http://www.nytimes.com>
- McFadden D (1999) Rationality for economists. *J Risk Uncertain* 19(1–3):73–105
- Mehra R, Prescott E (1985) The equity premium: a puzzle. *J Monet Econ* 15:145–161
- Meier S (2007) A survey of economic theories and field evidence on pro-social behavior. In: Frey B, Stutzer A (eds) *Economics and psychology: a promising new cross-disciplinary field*. MIT Press, Boston
- Meier S, Stutzer A (2008) Is volunteering rewarding in itself. *Economica* 75(297):39–59
- Menges R, Schroeder C, Traub S (2005) Altruism, warm glow and the willingness-to- donate for green electricity: an artefactual field experiment. *Environ Resour Econ* 31:431–458
- Milinski M, Semmann D, Krambeck HJ, Marotzke J (2006) Stabilizing the Earth's climate is not a losing game: supporting evidence from public goods experiments. *Proc Natl Acad USA* 103(11):3994–3998
- Moore E, Eckel C (2003) Measuring ambiguity aversion. Unpublished manuscript, Department of Economics, Virginia Tech
- Mullainathan S, Thaler R (2000) Behavioral economics. Working Paper No. 00-27, MIT Department of Economics
- Munda G (2004) Social multi-criteria evaluation (SMCE): methodological foundations and operational consequences. *Eur J Oper Res* 158/3:662–677
- Nannen V, van den Bergh JCJM (2010) Policy instruments for evolution of bounded rationality: application to climate-energy problems. *Technol Forecast Soc Change* 77(1):76–93
- Nash J (2006) Framing effects and regulatory choice: the case of environmental regulation. *Notre Dame Law Rev* 82(313):355–369
- Norton B, Costanza R, Bishop RC (1998) The evolution of preferences: why 'sovereign' preferences may not lead to sustainable policies and what to do about it. *Ecol Econ* 24:193–211
- Noussair C, Tucker S (2005) Combining monetary and social sanctions to promote cooperation. *Econ Inq* 43:649–660
- O'Connor RE, Bord RJ, Yarnal B, Wiefek N (2002) Who wants to reduce greenhouse gas emissions? *Soc Sci Q* 83:1–17
- O'Donoghue T, Rabin M (1999) Incentives for procrastinators. *Q J Econ* 114(3):769–816
- O'Donoghue T, Rabin M (2000) The economics of immediate gratification. *J Behav Decis Mak* 13:233–250

- Ostrom E (1990) *Governing the commons: the evolution of institutions for collective action*. Cambridge University Press, Cambridge
- Ostrom E, Walker J, Gardner R (1994) *Rules games and common-pool resources*. University of Michigan Press, Ann Arbor
- Ostrom E (1998) A behavioral approach to the rational choice theory of collective action. *Am Polit Sci Rev* 92(1):1–22
- Ozaki R (2009) Adopting sustainable innovation: what makes consumers sign up to green electricity? *Bus Strategy Environ* 18(5)
- Patt AG, Schröter D (2008) Perceptions of climate risk in Mozambique: implications for the success of adaptation strategies. *Glob Environ Change* 18:458–467
- Pichert D, Katsikopoulos KV (2008) Green defaults: information presentation and pro-environmental behaviour. *J Environ Psychol* 28:63–73
- Postlewaite A (1998) Social status, norms and economic performances: the social basis of interdependent preferences. *Eur Econ Rev* 42:779–800
- Rabin M (1993) Incorporating fairness into game theory and economics. *Am Econ Rev* 83(5):1281–1302
- Rabin M (1998) Psychology and economics. *J Econ Lit* 36(1):11–46
- Rand D, Nowak M (2009) How reputation could save the Earth. *New Sci* 2734:28–29
- Rauscher M (2006) Voluntary emission reductions, social rewards, and environmental policy. CESifo Working Paper No. 1838, Munich
- Read D, Loewenstein G, Rabin M (1999) Choice bracketing. *J Risk Uncertain* 19(1–3):171–197
- Rege M, Telle K (2004) The impact of social approval and framing on cooperation in public good situations. *J Public Econ* 88:1625–1644
- Risbey JS, Kandlikar M (2007) Expressions of likelihood and confidence in the IPCC uncertainty assessment process. *Clim Change* 85:19–23
- Rodríguez-Sickert C, Guzmán RA, Cárdenas JC (2008) Institutions influence preferences: evidence from a common pool resource experiment. *J Econ Behav Organ* 67:215–227
- Rohdin P, Thollander P, Solding P (2007) Barriers to and drivers for energy efficiency in the Swedish foundry industry. *Energy Policy* 35:672–677
- Robson AJ (2001) The biological basis of economic behavior. *J Econ Lit* 39:11–33
- Robson A (2002) Evolution and human nature. *J Econ Perspect* 16(2):89–106
- Safarzynska K, van den Bergh JCJM (2010) Demand-supply coevolution with multiple increasing returns: policy analysis for unlocking and system transitions. *Technol Forecast Soc Change* 77(2):297–317
- Sanstad AH, Howarth RB (1994) Consumer rationality and energy-efficiency. In: *Proceedings of the 1994 ACEEE summer study on energy-efficiency in buildings 1: Human dimensions*. American Council for an Energy-Efficient Environment, Washington, DC
- Schleich J, Gruber E (2008) Beyond case studies: barriers to energy efficiency in commerce and the services sectors. *Energy Econ* 30:449–464
- Schwarz N, Ernst A (2009) Agent-based modeling of the diffusion of environmental innovations: an empirical approach. *Technol Forecast Soc Change* 76(4):497–511
- Sekulova F, van den Bergh JCJM (2010) On the happiness costs and benefits of climate change. Working Paper, ICTA-UAB, June 2010
- Settle C, Shogren J (2004) Hyperbolic discounting and time inconsistency in a native-exotic conflict. *Resour Energy Econ* 26(2):255–274
- Shleifer A (1999) *Inefficient markets: an introduction to behavioral finance*. Oxford University Press, New York
- Shogren JF (2002) A behavioral mindset on environmental policy. *J Socio-Econ* 31:355–369
- Shogren JF, Taylor LO (2008) On behavioral-environmental economics. *Rev Environ Econ Policy* 2(1):26–44
- Siebenhüner B (2000) Homo sustinens—Towards a new conception of humans for the science of sustainability. *Ecol Econ* 32(1):15–25
- Simon H (1955) A behavioral model of rational choice. *Q J Econ* 6:99–118
- Simon H (1959) Theories of decision-making in economics and behavioral science. *Am Econ Rev* 49(3):253–283
- Simon H (1986) Rationality in psychology and economics. *J Bus* 59(4):209–224
- Simon H (1992) Altruism and economics. *East Econ J* 18(1):73–83
- Slovic P, Tversky A (1974) Who accepts Savage's axiom. *Behav Sci* 19:368–373
- Slovic P, Fishhoff B, Lichtenstein S (1982) Why study risk perception. *Risk Anal* 2(2):83–93
- Smith VL (1991) Rational choice: the contrast between economics and psychology. *J Polit Econ* 99:877–897
- Spash CL, Hanley N (1995) Preferences, information and biodiversity preservation. *Ecol Econ* 12(3):191–208
- Stern P (1992) What psychology knows about energy conservation. *Am Psychol* 47(10):1224–1232

- Stern PC (2000) Toward a coherent theory of environmentally significant behavior. *J Soc Issues* 56(3):407–424
- Stutzer A, Frey B (2006) What happiness research can tell us about self-control problems and utility misprediction. In: McCaffery EJ, Slemrod J (eds) *Behavioral public Finance*. Russell Sage Foundation, New York, pp 113–140
- Sugden R (2005) Coping with preference anomalies in benefit-cost analysis: a market-simulation approach. *Environ Resour Econ* 32:129–160
- Sugden R (2009) Market simulation and the provision of public goods: A non-paternalistic response to anomalies in environmental evaluation. *J Environ Econ Manage* 57(1):87–103
- Thaler R (1980) Towards a positive theory of consumer choice. *J Econ Behav Organ* 1:39–60
- Thaler R (1999) Mental accounting matters. *J Behav Decis Mak* 12:183–206
- Thaler R, Shefrin H (1981) An economic theory of self-control. *J Polit Econ* 89(2):392–406
- Titmuss R (1970) *The gift relationship: from human blood to social policy*. Allen and Unwin, London
- Tversky A, Thaler R (1990) Preference reversals. *J Econ Perspect* 4(1):193–205
- van den Bergh JCJM, Ferrer-i-Carbonell A, Munda G (2000) Alternative models of individual behaviour and implications for environmental policy. *Ecol Econ* 32(1):43–61
- van den Bergh JCJM (2008) Environmental regulation of households? An empirical review of economic and psychological factors. *Ecol Econ* 66:559–574
- van den Bergh JCJM, Kallis G (2009) Evolutionary policy. *Papers on Economics and Evolution* 2009-02, Max Planck Institute of Economics, Evolutionary Economics Group
- van den Bergh JCJM (2010) Safe climate policy is affordable—12 reasons. *Clim Change* (forthcoming). doi:10.1007/s10584-009-9719-7
- van Raaij WF, Verhallen TMM (1983) Patterns of residential energy behavior. *J Econ Psychol* 4(1):85–106
- Vatn A (2005) Rationality, institutions and environmental policy. *Ecol Econ* 55:203–217
- Veblen T (1899) *The theory of the leisure class*. MacMillan, New York
- Velez MA, Stranlund JK, Murphy JJ (2009) What motivates common pool resource users? Experimental evidence from the field. *J Econ Behav Organ* 70:485–487
- Venkatachalam L (2008) Behavioral economics for environmental policy. *Ecol Econ* 67:640–645
- Verplanken B, Aarts H (1999) Habit, attitude, and planned behaviour: is habit an empty construct or an interesting case of automaticity?. *Eur Rev Soc Psychol* 10:101–134
- Viscusi WK (1989) Prospective reference theory: toward an explanation of the paradoxes. *J Risk Uncertain* 2:235–264
- Viscusi WK (1995) Government action, biases in risk perception, and insurance decisions. *Geneva Risk Insur Rev* 20(1):93–110
- Viscusi WK, Zeckhauser RJ (2006) The perception and valuation of the risks of climate change: a rational and behavioral blend. *Clim Change* 77:151–177
- Wakker P, Timmermans D, Machielse I (2007) The effects of statistical information on risk and ambiguity attitudes, and on rational insurance decisions. *Manage Sci* 53:1770–1784
- Weiss Y, Fershtman C (1998) Social status and economic performance: a survey. *Eur Econ Rev* 42:801–820
- Wender R (2005) Frames of reference, the environment, and efficient taxation. *Econ Gov* 6:13–31
- Wertenbroch K (1998) Consumption self-control by rationing purchase quantities of virtue and vice. *Mark Sci* 17(4):317–337
- Wilson C, Dowlatabadi H (2007) Models of decision making and residential energy use. *Annu Rev Environ Resour* 32:169–203
- Winter SG (1964) Economic ‘natural selection’ and the theory of the firm. *Yale Econ Essays* 4:225–272
- Witt U (2003) Economic policy making in evolutionary perspective. *J Evol Econ* 13:77–94
- Yarnal B, O'Connor RE, Shudak R (2003) The impact of local versus national framing on willingness to reduce greenhouse gas emissions: a case study from central Pennsylvania. *Local Environ* 8(44):457–469
- Zeckhauser R, Viscusi WK (1990) Risk within reason. *Science* 248:559–564